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# The commodities' financialization : price formation and co-movements

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**La financiarisation des matières premières et des marchandises :  
formation des prix et co-mouvements**



THESE



En vue de l'obtention du DOCTORAT ÈS SCIENCES DE GESTION

Spécialité : Finance



Présentée par

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# Remerciements

# Résumé et mots clés

L'objet de cette thèse est d'examiner les effets de la financiarisation sur les marchés des matières premières et des marchandises. En particulier, nous nous intéressons à ses deux leviers d'action ; le levier informationnel et le levier des corrélations entre ces marchés. Cette thèse est composée de trois chapitres qui peuvent être lus indépendamment.

Dans le premier chapitre, nous étudions l'impact informationnel des annonces de production de l'OPEP sur le prix du pétrole entre 1991 et 2015. Dans notre analyse, nous employons l'étude des événements en y associant, à la différence de la littérature pertinente, un modèle EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedastic) pour prendre en compte le caractère volatil du prix de pétrole. De plus, nous utilisons deux indices de prix de pétrole (Le Western Texas Intermediate (WTI) et le BRENT). Nos résultats donnent un aperçu nouveau sur le rôle de l'OPEP. En particulier, ce rôle dépend du niveau de prix de pétrole et est plus prononcé quand ce dernier est faible. En outre, les annonces de maintien et de coupure de la production sont les plus influentes dans cet ordre. Enfin, les effets de ces annonces sont différents selon l'indice utilisé.

Le deuxième chapitre est une suite du premier chapitre dans la mesure où nous y analysons les effets des mêmes annonces de l'OPEP avec l'association de l'étude des événements et un modèle EGARCH. Cependant, ce chapitre s'en distingue en ce qu'il porte sur l'analyse de l'effet des mêmes annonces sur le marché action et utilise un modèle Fama French à 3 facteurs au lieu du modèle de marché. Par ailleurs, cette étude se distingue aussi par son ampleur puisqu'elle englobe tous les secteurs économiques. Les résultats de ce chapitre apportent un éclairage nouveau sur l'influence de l'OPEP sur ces marchés. Cette dernière semble plus prononcée en période de fortes fluctuations des prix de pétrole avec des différences inhérentes à chaque industrie. En outre, les annonces d'augmentation et de coupure de production sont les plus influentes.

Le dernier chapitre est consacré à l'analyse des effets de la financiarisation et leur pérennité sur la structure de dépendance des marchés des matières premières et des marchandises. Ce chapitre complète les deux derniers en ce qu'il permet d'explorer le deuxième levier d'action de la financiarisation ; le levier des corrélations entre les marchés des matières premières et des marchandises. Dans cette étude, nous utilisons le modèle ADCC (Asymmetric Dynamic Conditional Correlations) à des fins de modélisation des corrélations avec un modèle à

changements de régime markovien pour mettre en évidence les cycles d'évolutions de ces corrélations. Nos résultats jettent une lumière nouvelle sur les liens entre ces marchés. Plus précisément, ils indiquent une plus grande intégration de ces marchés et une altération des processus de découverte de prix.

**Mots-clés :** WTI (pétrole brut), BRENT (pétrole brut), étude d'événements, EGARCH, Fama French à 3 facteurs, modèle ADCC, modèle de Markov avec changement de régime.

# Abstract and key words

The purpose of this doctoral thesis is to examine the commodity's financialization impact on the commodity markets. In particular, we focus on its two main consequences; namely the informational role and the correlation between the commodities markets. This thesis consists of three chapters that can be read independently.

In the first chapter, we examine the OPEC's production announcements' informational impact on crude oil's price between 1991 and 2015. In this analysis, we employ the event study methodology in association with an EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedastic) model, unlike the relevant literature, to take into consideration the volatile nature of crude oil prices. In addition, we use two different crude oil price benchmarks (The Western Texas Intermediate (WTI) and the BRENT). Our methodology provides us with some new results. Especially, OPEC's role depends on the crude oil's price level and is more pronounced when this level is low. Moreover, the maintain and the cut production announcements are the most influential. However, their effect is different depending on the benchmark used.

The second chapter is very similar to the previous chapter as it employs the same methodology to analyze the effects of OPEC's announcements. Nevertheless, in sharp contrast to the previous chapter and unlike the existing literature, this chapter examines OPEC's production decisions impact on stocks prices including all the economic sectors by appropriately using a 3-factor Fama French model. Our results indicate that OPEC's announcements effect is higher during oil price's turbulent times and depends on industries specific characteristics. Furthermore, the increase and cut production announcements are the most significant respectively.

The last chapter is dedicated to the second aspect of the financialization phenomenon examined in this thesis, that is the commodities dependence structure. In this study, we employ the ADCC (Asymmetric Dynamic Conditional Correlations) to model the correlations in association with a Markovian changing regimes model to highlight the correlations cycle evolution over time. Our results show a greater integration of the commodities markets and an alteration of the price discovery process.

**Key words:** WTI (crude oil), BRENT (crude oil), event study, EGARCH, 3 factor Fama French, ADCC model, Markovian changing regimes model.

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# Introduction générale

Durant les deux dernières décennies, les marchés des matières premières et des marchandises ont connu un regain d'intérêt de la part des investisseurs. Cet engouement a eu pour effet un afflux massif d'investissement et a conduit à plusieurs mutations dans le fonctionnement de ces marchés. Ainsi, les investissements dans ces marchés sont passés de 15 milliards de dollars en 2003 à 200 milliards de dollars au premier semestre de 2008<sup>1</sup>. A la suite de ces changements, régulateurs et chercheurs s'y sont aussi intéressés afin de mieux comprendre les mécanismes derrière ce nouvel état de marché et espérer ainsi mieux les réguler. Ces transformations sont mieux connues sous l'appellation générique de « financiarisation » des marchés des matières premières et des marchandises.

D'une manière générale, ce phénomène décrit le rôle grandissant des marchés et des acteurs financiers dans le fonctionnement des marchés des matières premières et des marchandises. Traditionnellement, ces marchés ont été segmentés du reste des marchés financiers et ne comptaient qu'un nombre limité d'acteurs que l'on peut diviser en deux grandes catégories : les acteurs commerciaux et les acteurs non commerciaux<sup>2</sup>. Tout d'abord, Les acteurs commerciaux sont les producteurs et consommateurs de ces produits dont l'objectif est la couverture du le risque de fluctuations des prix. A titre d'exemple, les agriculteurs se couvriront contre le risque climatique alors que les producteurs de pétrole se couvriront contre le risque d'une demande faible. Ensuite, les acteurs non commerciaux sont les acteurs financiers dont le but est de diversifier leurs portefeuilles. Traditionnellement, les acteurs commerciaux constituaient la catégorie dominante dans ces marchés. A la suite de l'explosion de la bulle dite internet<sup>3</sup>, les acteurs financiers voient en les marchés des matières premières et des marchandises plusieurs avantages. Premièrement, ces produits peuvent générer des rendements similaires aux produits des marchés financiers dits « classiques »<sup>4</sup>. En effet, l'effondrement des marchés actions à la suite de la bulle internet ainsi que le niveau faible des taux d'intérêt a fait émerger ces produits comme des alternatives plausibles aux produits classiques de la finance. Deuxièmement, ces marchés étaient traditionnellement fragmentés et segmentés des marchés financiers classiques. En effet, leurs corrélations avec les marchés classiques étaient très faibles. En

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<sup>1</sup> Estimation donnée par la CFTC (Commodity Futures Trading Commission)

<sup>2</sup> Distinction par la CFTC (Commodity Futures Trading Commission)

<sup>3</sup> La bulle internet fait référence à la bulle financière des années 2000s où l'engouement pour les titres technologiques était sans commune mesure avec l'évolution de ce marché.

<sup>4</sup> Par marchés financiers classiques, nous entendons tous les marchés de tous les produits financiers qui ne font pas partie de la sphère des marchés des matières premières et marchandises.

conséquence, ces produits sont devenus des candidats naturels pour la diversification de portefeuilles<sup>5</sup>. Ces deux raisons principalement ont été les moteurs d'un investissement massif de la part des investisseurs institutionnels et particuliers dans des produits basés sur les matières premières et des marchandises<sup>6</sup>. Un afflux qui a enclenché le phénomène de financiarisation des matières premières et des marchandises.

Parmi les conséquences de ce phénomène sur le fonctionnement de ces marchés, deux retiennent notre attention et feront l'objet d'un développement dans la suite de cette introduction. La première a trait à l'interprétation de l'information par les acteurs de ces marchés tandis que la deuxième conséquence est liée à la corrélation des marchés des matières premières et des marchandises entre eux d'une part et à la corrélation entre ces derniers avec les marchés classiques.

Le premier aspect informationnel ne peut s'apprécier qu'en prenant en compte l'arrivée de nouveaux acteurs sur ces marchés et son impact sur leur fonctionnement.

La différenciation traditionnelle entre acteurs commerciaux et non commerciaux a donné place, plus récemment, à une structure des marchés des matières premières et des marchandises caractérisée par une classification plus fine distinguant cinq catégories d'acteurs<sup>7</sup>. En premier lieu, nous retrouvons la catégorie des acteurs sur le marché physique<sup>8</sup> aussi dénotée « PMPU ». La caractéristique première de cette catégorie est l'usage des « Futures » comme instrument de gestion des risques inhérents à la matière première ou marchandise exploitée. En second lieu, nous retrouvons la catégorie dite « Swap dealers »<sup>9</sup>. Cette catégorie se distingue par son usage des swaps et des instruments de couverture pour ces mêmes swaps. En troisième lieu, nous retrouvons la catégorie des « Money Managers »<sup>10</sup>. Les entités qui composent cette catégorie gèrent le compte de leurs clients dans les marchés des « Futures ». Enfin les deux catégories restantes sont respectivement désignées comme « Other reporting traders » et « Non-reporting traders ». La première désigne tous les acteurs qui ne correspondent pas aux catégories précédentes et qui rendent compte de leurs activités. La deuxième se réfère à tous les acteurs ne faisant pas partie des catégories évoquées plus hauts et qui ne sont pas obligés de rendre compte de leurs activités.

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<sup>5</sup> Cette thèse a été popularisée par quelques auteurs dont Gorton and Rouwenhorst (2006)

<sup>6</sup> Les investisseurs institutionnels investissent majoritairement dans les indices de matières premières et marchandises quant les particuliers utilisent plus généralement les ETFs (Exchange Traded Funds).

<sup>7</sup> Cette nouvelle classification est celle adoptée par la CFTC en 2009 afin de mieux cartographier les types d'acteurs présents dans les marchés des matières premières et marchandises.

<sup>8</sup> Cette catégorie comprend tous les acteurs qui opèrent dans les marchés physiques: les producteurs, les marchands, les transformateurs de ces produits et les acheteurs en bout de chaîne. Son sigle « PMPU » est formé par les initiales de ces acteurs (Producers, Merchants, Processors and Users)

<sup>9</sup> Cette catégorie se compose notamment de tous les acteurs qui ont trait à l'usage de swap. Dans cette catégorie, nous retrouvons notamment les investisseurs indiciels. Les indices les plus utilisés sont les gammes S&P ou Bloomberg dédiés aux matières premières et marchandises.

<sup>10</sup> Cette catégorie englobe des acteurs comme les hedge funds ou encore les ETFs.

Cette nouvelle cartographie des acteurs montre la prédominance des acteurs des marchés financiers classiques sur les acteurs traditionnels des marchés des matières premières et des marchandises et altère le fonctionnement de ces derniers. En effet, le rôle premier de ces marchés a été de faciliter la formation des prix pour les acteurs du marché physique. Ainsi, le prix de la matière première reflétait correctement l'état de l'offre et la demande et tout acteur du marché physique pouvait s'y fier comme un signal pour jauger ce dernier. Ainsi, le prix ne reflète plus seulement l'état de l'offre et la demande mais aussi l'état des marchés financiers classiques. En effet, les nouveaux acteurs opèrent sur de multiples marchés avec pour objectif de maximiser leurs rendements tout en minimisant leurs risques. A cet effet, leurs transactions ne sont pas motivées uniquement par l'équilibre offre/demande mais aussi par des informations externes aux marchés des matières premières et des marchandises. Le processus de formation de prix s'en trouve altéré et le prix n'est plus un signal fiable pour les acteurs du marché physique. Cependant, l'efficacité de ces marchés a été améliorée avec cette nouvelle pluralité d'acteurs. Nous retrouvons cette idée dans Bhar et Hamori (2006) qui ont étudié le marché des futures du Tokyo Grain Exchange et ont conclu à une plus grande efficacité de ces marchés entre 2000 et 2003 comparativement aux années 1990. (voir aussi, Jawadi et al. 2017, Bose, 2006, Switzer et El-Khoury, 2007 et Singh, 2010)

Cette altération est très marquée sur certains marchés des matières premières et des marchandises tels que l'or ou encore le pétrole car plus efficaces et liquides<sup>11</sup>. Par conséquent, nous nous intéressons au marché du pétrole pour illustrer cette conséquence de la financiarisation.

Le pétrole est une matière première vitale au fonctionnement des économies modernes. Historiquement, les variations de son prix ont été liées à des chocs d'offre. Ainsi, lors du premier choc pétrolier de 1973, l'incertitude de l'offre liée à l'état de l'embargo sur le long terme a eu comme résultat le quadruplement de son prix passant de 3\$ à 12\$ par baril. Pareillement, le second choc pétrolier de 1979, est dû à une diminution de la production de pétrole iranien passant de 6 millions de barils/jour à 1.5 millions barils/jour avec un prix de pétrole atteignant 39\$. Il est à noter qu'une littérature plus récente comme les travaux originaux de Killian (2009) suggèrent que les chocs pétroliers de la période 2000 à 2007 seraient des chocs de demande. Bien que cette hypothèse soit originale, la question de la nature des chocs- chocs de demande ou chocs d'offre- fait toujours l'objet de débat. Dans cette thèse,

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<sup>11</sup> Ici, nous faisons référence à la liquidité de ces deux marchés. En effet, de par leur popularité, ces derniers ont attiré de nombreux investissements et une grande variété d'acteurs. Ainsi, il est aisé, dans ces marchés, de trouver en face de chaque acheteur un vendeur et ainsi pouvoir exécuter ses transactions. Nous en voulons pour preuve le volume d'échanges que ces marchés ont enregistré durant les deux dernières décennies. A titre d'exemple, l'équivalent de 939 tonnes d'or a été échangé sur le London exchange en moyenne chaque jour en 2018. (Article du 20 novembre 2018, reuters.com)

nous privilégions la piste de l'offre. Nous examinons spécifiquement les déterminants de l'offre pétrolière, à travers les décisions en matière de production pétrolière de l'Organisation des Pays Exportateurs de Pétrole (OPEP).

Le choix de l'OPEP comme acteur fondamental de l'offre pétrolière se base sur deux éléments essentiels. D'une part, l'OPEP contribue à hauteur de 40% à la production mondiale en 2020 et à 60% des exportations pétrolières dans le monde. Par conséquent, de part cette part de marché importante, l'OPEP non seulement influence le prix du pétrole, mais aussi sa capacité de production est un indicateur significatif de l'état du marché pétrolier, notamment en période de tensions. D'autre part, l'OPEP compte des membres, comme l'Arabie Saoudite, avec une capacité de réserve importante<sup>12</sup>. A titre d'exemple, l'Arabie Saoudite a une capacité de réserve allant de 1.5 à 2 millions de barils de pétrole pour soutenir l'offre en cas de crise. Face au potentiel de cette entité à organiser une part majeure de l'offre pétrolière, la connaissance de son fonctionnement devient d'autant plus nécessaire afin d'évaluer sa capacité réelle d'influence<sup>13</sup>.

Tout d'abord, nous rappelons quelques faits sur l'OPEP en tant qu'organisation ainsi que sur son fonctionnement.

La création de l'OPEP est le fruit d'une volonté d'augmenter le prix du pétrole brut par les pays fondateurs et de s'émanciper de la domination des raffineries internationales plus connues sous le nom des « sept sœurs »<sup>14</sup>. C'est, ainsi, qu'en 1960, le Venezuela, l'Arabie Saoudite, l'Iran, l'Iraq et le Kuweit se réunissent à Bagdad et proclament la création de l'OPEP. Depuis sa création, le but affiché de l'OPEP est de se poser comme un acteur majeur dans la négociation du prix du brut et de stabiliser son cours sur le marché du pétrole. Il a réussi à s'installer dans la durée, à attirer de nouveaux membres et à jouer un rôle prédominant dans la fixation du prix de pétrole brut.

Depuis sa création à nos jours, l'OPEP a vu la composition de ses membres changer à plusieurs reprises. A la suite de sa création, l'OPEP a continué à s'élargir en incluant le Qatar dès 1961, l'Indonésie et la Libye en 1962, les Emirats Arabes Unis en 1967, l'Algérie en 1969, le Nigeria en 1971, l'Equateur en 1973 et le Gabon en 1975. Cette addition initiale a eu pour effet de porter la part de production de l'OPEP à près de 50% de la production mondiale à l'aube des années 1970. Cette expansion se poursuivra en incluant d'autres membres comme l'Angola en 2007, la Guinée équatoriale en 2017 ou encore la République du Congo en 2018. Si l'organisation a réussi à

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<sup>12</sup>La capacité de réserve (ou « sparecapacity ») désigne le volume de production pouvant être débloqué dans les 30 jours et maintenu pendant au moins 90 jours (cf. Agence Internationale de l'Energie –AIE).

<sup>13</sup>Par capacité réelle d'influence, nous nous intéressons précisément au rôle effectif de l'OPEP dans le marché du pétrole.

<sup>14</sup>Les « sept sœurs » désignent les sept raffineries multinationales, actrices majeures du paysage pétrolier. La liste des sept est à retrouver en « annexe ».

attirer de nouveaux membres depuis sa création<sup>15</sup>, elle n'a pas aussi bien réussi la stabilité des adhésions. En effet, certains membres ont quitté l'organisation définitivement comme les cas du Qatar en 2019 et de l'Equateur en 2020 et d'autres ont suspendu leur adhésion comme l'Indonésie en 2016. Enfin, certains membres encore ont quitté ou suspendu leur adhésion avant de redevenir membres. C'est le cas du Gabon qui quitte l'organisation en 1995 pour la rejoindre à nouveau en 2016. Ce changement de composition est indicatif de tensions au sein de l'organe de décision et nous amène à discuter du fonctionnement interne de l'OPEP.

Toute décision de l'OPEP est prise à l'occasion de conseils ou « meetings » de deux natures. En effet, certains meetings sont dits « ordinaires » et d'autres « extraordinaires ». Les meetings ordinaires sont généralement au nombre de deux par année et sont organisés indépendamment de la situation du marché pétrolier. Les meetings extraordinaires, quant à eux, sont décidés exceptionnellement quand la situation l'exige. Il est, à noter également, que le rôle de l'OPEP est aussi de mettre en perspective la situation de ses propres membres avec celle du marché pétrolier. A cet effet, dès les années 1980, les réunions de l'OPEP comptent des pays comme l'Egypte, la Russie, la Norvège, le Mexique et Oman comme observateurs afin de mieux accorder les politiques de production. Chaque réunion donne lieu, suite à un vote unanime, à une annonce de quota de production à respecter par les membres. Ces annonces sont au nombre de trois : le maintien du quota de la production, la réduction du quota de la production ou encore l'augmentation de la production de marché.

Ces annonces de quota de production ont le potentiel de signaler l'état du marché pétrolier, le rôle de l'OPEP et son influence et seraient une indication de l'état de la financiarisation de ce marché. En effet, dans un marché efficient, ces annonces qui sont prises à la suite de concertations indirectes avec les principaux producteurs mondiaux du pétrole devraient être immédiatement intégrées dans son prix. Tout effet de ces annonces sur le prix pourrait indiquer une inefficience du marché du pétrole.

L'objectif premier du chapitre 1 est précisément d'analyser l'impact de ces annonces sur le prix de pétrole sur la période allant de 1991 à 2015. Bien que nous utilisons l'étude d'événements à l'instar de la littérature pertinente, notre étude s'en différencie en y associant un modèle EGARCH (Exponential Generalized Auto Regressive Conditional Heteroskedasticity) pour intégrer dans la méthodologie de notre étude les faits stylisés de la volatilité du prix de pétrole. De plus, nous subdivisons notre période d'évaluation en 2 sous périodes (1991-2004 et

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<sup>15</sup>Les membres actuels de l'OPEP sont au nombre de 13 depuis Janvier 2020 et la liste complète est à retrouver dans la section "annexes".

2005-2015) pour prendre en compte les différentes dynamiques observés du prix de pétrole : une première sous-période d'augmentation uniforme des prix suivi d'une deuxième sous période caractérisée par une volatilité plus élevée des prix. Enfin, nous utilisons les rendements journaliers de deux références du prix de pétrole (le West Texas Intermediate (WTI) et le Brent) à des fins de robustesse.

Nos résultats indiquent que l'impact des annonces de l'OPEP dépend du type d'annonce, de l'indice retenu comme référence de prix ainsi que de la sous période considérée. D'une manière générale, l'effet des annonces de maintien ou de coupure de la production sont les plus significatifs avec des différences entre le WTI et le Brent. En outre, nos résultats montrent que l'influence de l'OPEP dépend de l'état du marché pétrolier.

Comme mentionné plus haut, le profil des acteurs des marchés des matières premières et des marchandises a évolué. Les nouveaux acteurs agissent sur plusieurs plateformes ou marchés dans le but d'optimiser leurs portefeuilles qui comprennent, suite au phénomène de financiarisation, outre ces matières, des actifs dits traditionnels. Ainsi, toute information- au sens de nouvelles ou annonces- sur un des marchés aura pour effet un réajustement des portefeuilles. Par conséquent, les informations émanant des marchés des matières premières et des marchandises peuvent influencer les marchés classiques et inversement. Le marché des actions est un excellent candidat. En effet, du point de vue macroéconomique, il est bien établi dans la littérature que le prix du pétrole est un indicateur avancé de l'activité économique et ses variations ont un effet positif ou négatif sur la croissance économique et sur l'inflation (Killian, 2009, Killian et Park, 2009, Narayan et Sharma, 2014). Par ailleurs, du point de vue microéconomique, son prix a un impact sur les résultats des entreprises qui utilisent directement ou indirectement le pétrole dans le processus de production. Il s'ensuit que le prix du pétrole affecte les rendements des actions. Examiner cette relation présente un intérêt majeur. Dans le même cadre informationnel du premier chapitre, nous nous interrogeons sur l'effet potentiel des annonces de l'OPEP sur les rendements des actions.

Le chapitre 2 reprend en partie le chapitre précédent avec l'objectif d'étudier l'effet des mêmes annonces de l'OPEP sur les marchés des actions sur la même période et ce avec la même décomposition en sous périodes (1991-2004, 2005-2015). Nous adoptons également la même méthodologie que dans le chapitre 1. En revanche, l'objet de ce chapitre diffère substantiellement du précédent dans le sens où notre étude porte sur le marché des actions. A cet effet, nous utilisons le modèle de Fama-French à trois facteurs qui est le plus approprié pour le marché des actions. Notre étude de grande ampleur, couvrant tous les secteurs économiques et portant sur un échantillon de 473

entreprises européennes, tente de combler une lacune de la littérature où effectivement très peu d'articles sont consacrés à ce sujet.

Nos résultats suggèrent que les annonces de coupure ou d'augmentation des quotas de productions sont les plus significatives. Comme pour le chapitre 2, les résultats sont plus prononcés durant la 2<sup>ème</sup> sous période avec des disparités inhérentes aux secteurs économiques.

Depuis le début des années 2000, un afflux massif et croissant des capitaux s'est orienté vers les marchés des matières premières et des marchandises et ces produits sont devenus des actifs financiers au même titre que les actions ou les obligations. Trois raisons essentielles expliquent cet afflux qui participe du phénomène de financiarisation. Premièrement, la faible corrélation (voire négative) entre ces produits et les actifs financiers classiques a incité les gérants des fonds à les utiliser pour diversifier leurs portefeuilles (Erb et Harvey, 2006 et Gorton et Rouwenhorst, 2006). Deuxièmement, comme l'inflation est étroitement liée aux fluctuations de leurs prix, ces produits peuvent servir comme des instruments de couverture contre l'inflation (voir entre autres Alagidede et Panagiotidis, 2012, Arnold et Auer, 2015 et Spierdijket Umar, 2015). Enfin, des opportunités d'arbitrage peuvent apparaître entre les différents marchés. Pour ces raisons, les nouveaux acteurs du marché des matières premières et des marchandises peuvent influencer leurs prix en dehors des considérations d'offre et de demande.

Plus particulièrement, la financiarisation a eu comme conséquence l'augmentation du niveau de la corrélation aussi bien entre ces matières et les actifs financiers qu'entre groupes de matières premières (Miffre, 2012, Tang et Xiong, 2012, Buyuksahin et Robe, 2013 et Silvennoinen et Thorp, 2013). Cette évolution de la corrélation soulève deux questions. En premier lieu, il convient de s'interroger sur les mesures de corrélation et sur les conclusions des différentes études quant au niveau de la corrélation. En second lieu, la tendance à la hausse constatée de la corrélation est-elle ponctuelle ou structurelle ? Bien qu'il n'existe pas de définition explicite et communément admise dans la littérature, ni de mesure unique des co-mouvements (Silvennoinen et Thorp, 2013, de Nicola et al., 2016 et Tang et Xiong, 2012 entre autres), la corrélation est l'une des mesures associée à ce terme générique pour analyser le sens et l'intensité des relations entre variables aléatoires. Nous avons opté, dans le troisième chapitre de cette thèse, pour les corrélations conditionnelles dynamiques, introduites par Engle (2002), qui permettent de mieux répondre à ces deux questions. En effet, ce modèle permet de prendre en compte l'évolution dans le temps de la corrélation et de contourner la complexité d'estimation des modèles multivariés (Multivariate-

GeneralizedAutoregressiveConditionalHeteroscedasticmodels ; Bollerslev et al. (1988)).Par ailleurs, malgré leur intérêt indéniable dans la modélisation de l'interdépendance des variables financières, ne donnent pas d'indication sur la stabilité de la structure de corrélation. Ainsi, il est utile d'utiliser des modèles dits « à changement de régimes » pour déterminer les phases d'évolution de cette structure.

L'objet du chapitre 3 est d'évaluer les comouvements entre les marchés des matières premières et des marchandises. L'intérêt est majeur pour les gérants de portefeuille et les régulateurs en particulier. Pour les premiers, connaître la structure de dépendance des marchés permet de mieux composer leurs portefeuilles et parfaire leurs couvertures. Pour les seconds, la connaissance de cette structure permet de mieux connaître les marchés et mieux les réguler. Dans ce chapitre, nous utilisons le modèle ADCC (Asymmetric Dynamic Conditional Correlations) pour examiner, pendant la période de 1998 à 2018, les corrélations des sous-indices (métaux industriels, métaux précieux, agriculture et énergie) des matières premières et des marchandises Rogers. Puis nous nous référons à un modèle à changements de régime markoviens afin d'étudier l'existence et la nature des régimes structure de corrélation

Nos résultats permettent de mieux comprendre le phénomène de financiarisation et de valider certaines observations qui la caractérisent. Ainsi, nous observons une augmentation du niveau de corrélation moyen entre tous les différents marchés de matières premières et ce même en l'absence parfois de lien économique. En outre, nos résultats indiquent la présence de régimes persistants dans une majorité des cas avec des changements de régimes très rapides. Ce résultat est indicatif d'une plus grande intégration entre ces marchés comme conséquence de la financiarisation.

Cette thèse doctorale est organisée comme suit. Le premier chapitre est consacré à l'impact des annonces de production de l'OPEP sur le prix du pétrole (WTI et Brent), alors que le deuxième chapitre, dans le même esprit, mais dont l'objet diffère, porte sur l'effet de ces mêmes annonces sur le rendement des actions européennes de tous les secteurs économiques. Enfin, le troisième chapitre est orienté vers les conséquences de la financiarisation en s'intéressant à la corrélation entre les sous-indices des matières premières et des marchandises.



# Chapitre 1

## Do OPEC announcements influence oil prices?

### 1. Introduction

The 1973 oil crisis and the major economic and geopolitical events ( see, for instance, Salameh, 2014) since then shed light on the economic vital importance (see Bollino, 2007) of oil prices and their high level of volatility, as well as the role played by the Organization of Petroleum Exporting Countries (OPEC) in oil markets. Indeed, its members produce 40% of the world's crude oil and their exports represent about 60% of the traded oil internationally (see Matsumoto et al., 2012). The impact of OPEC decisions about the production level (increase, cut or maintain) on oil prices is a controversial issue among policy makers, regulators, and academics in particular. For some, this impact is weak or has been declining over time, especially lately as more and more non-OPEC producing countries increase their market share. For others, the impact is strong as prices deviate from their competitive level when members modify their oil production. Finally, there are some who support the viewpoint that OPEC's impact changes over time as a result of prevailing market conditions. The role of OPEC may also be scrutinized through the lens of the recent evolution of oil prices and the exploration of new oil resources. Indeed, we have seen oil prices not only breaking the \$40/bbl long-run level but staying for a long time at \$80/bbl, which is the level that makes the exploration and extraction of more expensive/unconventional oil resources economically viable (for instance, US shale oil, Canada's tar sands, Brazil's deep-sea offshore oil, Venezuela's heavy oil, and Arctic offshore oil, among others). Moreover, it is estimated that these resources represent about 50% of the global oil and gas proven reserves, thus increasing the importance of other non-OPEC producing countries still more on the global energy scene and reducing the influence on global oil prices of OPEC announcements. In this paper, we investigate the informational role of OPEC and its (potential) contribution to oil price formation. Our aim is to examine, by using the event study methodology (see, for instance, MacKinlay, 1997), how OPEC announcements can affect oil prices, which are characterized by a time-varying volatility.

The consequences of OPEC power on oil prices have been analyzed, through the market structure, in the literature (Bina and Vo, 2007; Fattouh and Mahadeva, 2013). Models often consider OPEC as a cartel, whose members can collude, manipulating prices through production quotas, resulting in monopolistic profits (see, among others, Ezzati, 1976; Pindyck, 1978; Adelman, 1980, 1982; Salant, 1982; Aperjis, 1982; Griffin, 1985; Smith, 2005). An alternative view is based on market competition, suggesting that the oil market is competitive and therefore OPEC has little influence on oil prices by operating as a cartel (Crémer and Salehi-Isfahani, 1980, 1989; MacAvoy, 1982; Teece, 1982). Empirical evidence for these two explanations of OPEC behavior has yielded conflicting results (see, for instance, Loderer, 1985; Griffin, 1985; Gülen et al., 1996; Alhajji and Huettner, 2000; Kaufmann et al., 2004, Smith, 2005). Geroski et al. (1987), Griffin and Neilson (1994), Brémond et al. (2012) and Fattouh and Mahadeva (2013) argue that OPEC's behavior varies over time depending on economic, market, and geopolitical conditions and cannot be represented by a single model. The 2000s, characterized by the financialization of commodity markets, brought the role of information in price formation to the fore. Thus, instead of directly modeling OPEC's behavior, another strand in the literature empirically studies the effect of OPEC's announcements of production changes on oil prices.

Few papers deal with the OPEC announcements and even fewer employ the event study methodology<sup>16</sup>. The first attempt to examine this topic was made by Draper (1984), who, by means of an event study on heating oil futures prices returns between fall 1978 (when NYMEX first introduced these futures contracts) and 1980, concluded that investors anticipated OPEC's announcements. However, the period is very short and the contract under scrutiny does not represent the OPEC basket of crude oil contracts. Deaves and Krinsky (1992) analyzed crude oil as well as heating oil futures returns over a longer period, distinguishing favorable and unfavorable news for investors who take long positions. They found that traders earn economically and statistically significant abnormal returns after an OPEC conference conveying "good news". They conclude that their results do not support the market efficiency hypothesis.

More recent studies have been conducted by several authors. Guidi et al. (2006) separated the whole period, 1986–2004, into conflict and non-conflict sub-periods. However, not only are the sub-periods short but also the

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<sup>16</sup> See also Kaufmann et al. (2004), Wirl and Kujundzic (2004) and Mensi et al. (2014), who use other econometric methods to examine the same topic.

authors are mainly interested in the impact of OPEC conferences on stock markets. Although their results seem to validate market efficiency, they detected an asymmetric reaction to OPEC's decision during periods of conflict between United States and United Kingdom stock markets. Hyndman (2008) studied how crude oil spot and two-month futures prices, as well as prices of oil-related company stocks, reacted to OPEC's announcements during 1986–2002. His results indicate that abnormal returns are statistically significant. However, he did not specify the model that allowed him to calculate abnormal returns. Lin and Tamvakis (2010) enriched the analysis over a long period, 1982–2008, by examining the impact of OPEC's announcements on OPEC and non-OPEC crude oil, and for different oil qualities. Their empirical evidence suggests that the effect of OPEC's decision depends on the production quotas (increase, cut, or status quo) and on the price trend. In contrast, they did not find a significant difference between OPEC and non-OPEC crudes or between oil qualities. The computation of abnormal returns is not based on any model, but rather on the average daily return of the estimation period. By examining both OPEC's and US Strategic Petroleum Reserve (SPR) announcements over the period 1983–2008 on spot and futures prices, Demirer and Kutan (2010) found positive significant cumulative abnormal return (CAR) differences for OPEC production decreases during the post-event period, whereas SPR announcements did not affect these differences. Although the authors used three different models to assess abnormal returns (the market model, the autoregressive conditional heteroskedasticity (ARCH) model, and the three-factor Fama-French model), they did not indicate how the Fama-French model might be applied to spot and future oil prices. Moreover, by performing a statistical test on the difference between the CARs of the last and the first day of the post-announcement period, the authors examined a form of static persistence. Finally, instead of studying OPEC's announcements, Brunetti et al. (2010) analyzed the effect of OPEC members' "fair price" statements on nearby futures crude oil prices from 2000 to 2009. They found that these statements have a limited influence on crude oil prices.

The dramatic fluctuations in oil prices have led some authors to investigate the relation between OPEC's announcements and the volatility of oil prices. Taking the period from 1989 through 2001 and employing an event study period, Horan et al. (2004) explored how and whether the implied volatility of crude oil option prices react to OPEC's announcements. Their results suggest that implied volatility increases before announcements and decreases the first day following OPEC's meetings. Other authors have opted for a study of realized volatility of oil price returns. Using intraday returns of crude oil and natural gas futures contracts over a five year period (1995–1999),

Wang et al. (2008) found strong evidence of a positive impact of a production increase announcement on weekly volatility, but no evidence of impact on daily volatility. Bina and Vo (2007) tried to detect the effect of OPEC production decisions on spot and futures oil prices as well as in the OPEC production quota changes following oil price fluctuations (1983–2005). They argued that OPEC decisions cannot reduce oil price volatility and that production adjusts to spot and futures oil price fluctuations in an expected manner. Schmidbauer and Rösch (2011), for the period 1986–2009 and for daily data, concluded that the impact of OPEC's decisions on volatility is anticipated by investors, as there is a positive effect before the announcements and an asymmetric effect on expected returns after the announcements.

The purpose of this paper is to investigate the influence on oil prices of OPEC's announcements in a framework of event studies. Our dataset covers the period from March 1991 to February 2015, including, unlike existing papers, the sharp fluctuations in oil prices of 2008 (a sharp increase followed by an important decrease before another pronounced increase), characterized by a high level of volatility. We divide the period into two sub-periods (1991–2004 and 2005–2015): during the first sub-period, prices uniformly increased, while the second sub-period was much more turbulent and prices were much higher. This allows us both to examine if oil prices reacted distinctly to OPEC's announcements during these two periods and to assess the robustness of our results. We consider daily returns of West Texas Intermediate (WTI) and Brent returns and OPEC's announcements of drop, status quo, or increase oil production. To compute abnormal returns, we use the market model, with the residuals modeled by an Exponential GARCH (EGARCH) process, developed by Nelson (1991), in order to capture the random volatility of oil prices. To the best of our knowledge, in the event studies setting applied to OPEC's announcements, Bina and Vo (2007) have been the only one to date to use GARCH residuals. However, two stylized facts characterize the volatility behavior of asset prices and oil prices in particular: first, the existence of an asymmetric response of volatility to positive and negative past returns and, second, the persistence of shocks for the estimates of volatility (see Narayan and Narayan, 2007; Ewing and Malik, 2010; Wei et al., 2010). The EGARCH model is able to represent these observed properties. For the empirical tests, as a proxy for the market portfolio, we use two different popular commodity indices, the Goldman Sachs-Standard and Poors Commodity Index (S&PGSCI) and the Bloomberg Commodity Index (BCI), as well as their energy counterparts. Thus we are able to assess the sensitivity of our results to different indices and to complement the existing literature.

Empirical evidence shows that the second sub-period is at variance with the first sub-period, depending on the OPEC decision. OPEC behavior seems to change during distinct periods, and its role is perceived differently by market participants. With regard to the nature of OPEC's decisions, our findings globally confirm those obtained by the aforementioned studies. In particular, the reaction of oil prices to these decisions is asymmetric, in the sense that the effect of production cut and maintenance decisions is more significant. However, the impact of OPEC's announcement on oil prices differs when considering WTI prices or Brent prices. Similarly, the choice of the index may lead to contrasting results, reflecting the weight of oil in each index, as well as the specific weight of WTI or Brent in each index.

The remainder of the paper is organized as follows. The data and methodology are described in section 2. Section 3 presents and discusses our empirical findings. Finally, section 4 offers some concluding remarks and the policy implications of our findings.

## **2. Data and methodology**

In this section, we first focus on describing the data used and briefly present the event study methodology applied.

### **2.1 Data description**

The data consist of all daily spot prices obtained from Thomson Reuters Datastream and the Energy Information Administration (EIA) from March 1991 to February 2015 for WTI and Brent crude oil. Figure 1 shows that WTI and Brent prices steadily but slowly increased from 1991 to 2004, radically changing in their pace of growth and attaining very high values in July 2008. Then prices sharply decreased, before increasing again in mid-2009. Moreover, these two periods are characterized by different levels of volatility. Consequently, we consider three different panels of data: panel A for the whole period (6291 daily observations), panel B from March 1991 to December 2004 (3652 daily observations), and panel C from January 2005 to February 2015 (2639 daily observations).

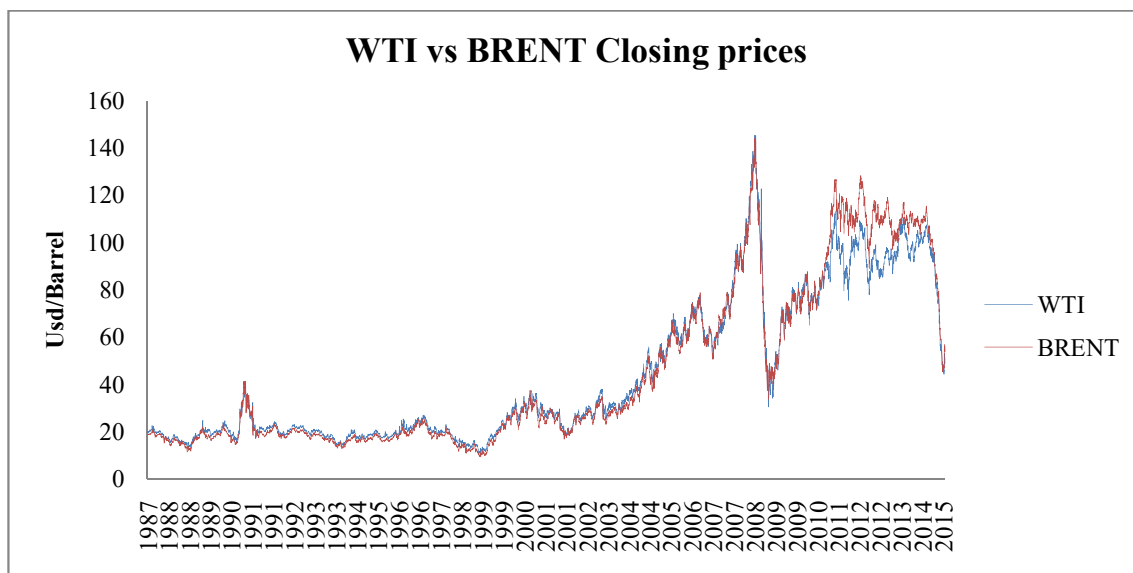


Fig.1. WTI and Brent closing prices from 1987 to 2015. (Sources: Datastream and EIA)

In regards to the two benchmark indexes used, at first, the BCI is a broadly diversified index and is currently composed of 22 commodities traded on US exchanges, with the exception of aluminum, nickel, and zinc, which trade on the London Metal Exchange (LME). On the other hand, S&P GSCI is a world production index that is well diversified, both across commodity sub-sectors and within each sub-sector. Currently, it contains 24 commodities from all sectors. The energy counterparts of these two indices contain oil and its derivatives and gas, namely WTI crude oil, Brent crude oil, heating oil, gasoil, RBOB gasoline and natural gas.

Table 1 displays some descriptive statistics for our sample oil prices. The mean of spot prices is around \$45, while the volatility is around 30% to 35%. The skewness is positive, while kurtosis is close to 3. Finally, the Jarque–Bera test indicates, as expected, that neither oil price is normally distributed.

Table 1  
Descriptive statistics for WTI and BRENT

	WTI	BRENT
Mean	44.02983	44.69327
Median	27.66	26.2
Maximum	145.31	144.07
Minimum	10.82	9.22
Std. Dev.	31.21955	34.84428
Skewness	0.910438	0.988786
Kurtosis	2.450665	2.522983
Jarque–Bera	1090.785***	1247.88***
Observations	7237	7237

Note: \*\*\*/\*\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively.

OPEC decisions on oil production are made during OPEC conferences, which take place at least twice a year. In addition to these regular meetings, if market conditions require, extraordinary meetings can be held during the year. The decisions may take the form of quota reductions, increases, or maintenance of the status quo. A formal announcement is made at the end of each conference with the cartel's decision. In our methodology, these announcements are considered as the event day. During the whole sample period, as shown in Table 2, there were 83 announcements; of which 47 refer to a production status quo, 19 to a production cut, and 17 to a production increase.

## 2.2 The methodology

To investigate the effects of OPEC announcements on crude oil prices, we use an event study methodology. It has widely been applied to many fields in financial economics but less frequently to oil prices and OPEC decisions. Event studies examine the behavior of abnormal returns of a security around a relevant event. In our case, events are announcements made by OPEC about its oil production output. The incorporation of the information, following an event, in asset prices may be immediate or may spread out over time. The choice of the event window is not based on formal rules and can differ among different studies. We opt for an event window of five days before and after the announcement (see also Horan et al., 2004; Bina and Vo, 2007). This choice is based on several concerns: to capture information leakages before the OPEC announcement, to take into account the reaction of oil prices after the announcement, to prevent overlapping among OPEC meetings (in the case of extraordinary meetings), and to avoid contamination from other events.

The assessment of the event's impact on asset prices can be measured by the abnormal return ( $AR_t$ ), which is defined as follows:

$$AR_t = R_t - E(R_t)$$

where  $R_t$  is the daily log return on crude oil at date  $t$  and  $E(R_t)$  is the normal return, which is the expected log return at date  $t$  over a period other than the event window. This expectation is not conditional on the information related to the event.

Abnormal returns are used to compute cumulative abnormal returns (CARs) as the sum of the daily abnormal returns over the event window:

$$CAR_t = \sum_{i=-5}^{+5} AR_t$$

The normal returns can be estimated (see also MacKinlay, 1997) by the market model or factor models (Draper, 1984; Demirer and Kutan, 2010), by autoregressive models (Bina and Vo, 2007), or by the constant mean return model (Guidi et al., 2006, Lin and Tamvakis, 2010)<sup>17</sup>. The strong assumption of homoscedasticity in oil price time-series is relaxed in some papers in which the variance of residuals follows an ARCH process (Deaves and Krinsky, 1992; Demirer and Kutan, 2010) or a GARCH process (Bina and Vo, 2007). Indeed, high price volatility is a feature of oil markets, and there is strong evidence supporting heteroscedasticity in oil prices (see, among others, Morana, 2001; Narayan and Narayan, 2007; Mohammadi and Su, 2010). In this paper, the normal returns are measured by two equations: the market model with homoscedastic residuals (eq. 1) and the market model with EGARCH residuals to capture asymmetric variance effects (eq. 2).

$$R_t = \alpha + \beta R_{mt} + \varepsilon_t \quad (1)$$

$$E(\varepsilon_t) = 0 \text{ And } Var(\varepsilon_t) = h_t^2 \quad (2)$$

$$\log(h_t) = \omega + \sum_{i=1}^p a_i \log(h_{t-i}) + \sum_{j=1}^q b_j \left( \left| \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} - \sqrt{\frac{2}{\pi}} \right| + \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} \right) \quad (3)$$

Where  $R_t$  and  $R_{mt}$  are the returns at date  $t$  on crude oil and the market portfolio, respectively, and  $\varepsilon_t$  is the disturbance term.  $\alpha$  and  $\beta$  are the parameters of the market model, and are constants.  $h_t$  is the volatility term,  $\omega$  is the constant, where  $a_i$  and  $b_j$  are the weights of the lagged log volatilities and the corrective terms of the models, respectively.

The EGARCH model has some advantages compared to the GARCH model and incorporates some features in oil price volatility. First, unlike the GARCH model, it does not require the imposition of nonnegative constraints on the parameters  $\alpha$ ,  $\beta$ , and  $\gamma$ , since the variance is automatically constrained to be positive, as the conditional variance is specified in the logarithmic form. Second, it accounts for an asymmetric reaction of volatility to a shock observed in many financial series, which is captured by the parameter  $\gamma$ . A positive parameter implies that a positive shock results in a higher future conditional volatility than a negative shock of the same magnitude and vice

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<sup>17</sup>MacKinlay (1997) suggested that the market model should behave better, in terms of variance reduction of the abnormal return, than the constant mean return model.



versa<sup>18</sup>. Third, the EGARCH model is stationary if  $|a| < 1$ . The persistence of a shock can be assessed through the estimate of the latter parameter (see Narayan and Narayan, 2007). For the market portfolio, as a market-wide index, we use two different commodity indices, BCI and S&PGSCI, and their energy counterparts, all widely accepted by investors. Using these two indices allows us to test the dependence of the results on the choice of the index.

Once the abnormal returns have been obtained, we perform significance tests on the effect of OPEC's three decisions on oil prices. The null hypothesis indicates that these decisions have no impact on oil prices. In other words, we test whether  $AR_t$  and  $CAR_t$  are significantly different from zero for each day within the event window. We make use of the cross-sectional parametric test suggested by Corrado (2011), Bina and Vo (2007), and Savickas (2003), which addresses both the conditionally heteroskedastic behavior of volatility and the event-induced variance changes. The t-statistic is formulated as follows:

$$Test = \frac{SCAR_{it}}{\sigma_{SE}}$$

Where  $SCAR_{it} = \sum_{-5}^{+5} \frac{AR_{it}}{\sqrt{\hat{h}_{it}}}$

After the choice of the normal model, the final step is to determine the estimation period. Although there is no procedure for the definition of this period, usually a pre-event window period is used to avoid the impact of the event on the estimation of the parameters of the normal model. In this paper, the estimation period is obtained by removing the event windows from the initial samples and aggregating the obtained series. This procedure allows us to capture more events.

### 3. Empirical results and discussion

In this section, we present the results for both WTI and Brent crude oil, for each index, for the three types of OPEC's decisions, as well as for the three sub-periods. Tables 2 and Figure 2 show CARs and their paths respectively for an increase in quotas announcements. According to other existing studies (Guidi et al., 2006; Bina and Vo, 2007; Lin and Tamvakis, 2010; Demirer and Kutan, 2010; Schmidbauer and Rösch, 2011; Mensi et al., 2014), whatever the commodity index and the oil price chosen, the results are generally not statistically significant. These results can be explained by OPEC's so-called "cheating" behavior—showing no respect for the

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<sup>18</sup> This effect has been observed in several commodity prices' volatility levels (see Bowden and Payne, 2008). When  $\gamma$  is negative, the effect is called the leverage effect, which characterizes many financial assets.

quotas allocated to OPEC’s members—with the tendency to increase their production above the agreed quotas (Kaufmann et al., 2004; Lin and Tamvakis, 2010; Colgan, 2011). For example, Colgan (2011) has reported a 10% excess in production over OPEC members’ quota from 1982 to 2009. OPEC may thus anticipate “cheating” by its members and adapt quotas accordingly. More generally, OPEC may endorse unilateral decisions made previously by its members. Another argument is put forward by Hyndman (2008). He explains the low significance of results by the fact that it is easier for OPEC’s members to agree on a quota increase, a behavior that can be readily anticipated by the market. Market participants do not react to an increase in production, as they seem to expect such decisions. However, the significance improves for the energy counterpart of the indices, as oil is a major constituent (except for WTI during the first sub-period, relative to BCI). For the vast majority, there is a significant impact on CARs after the announcement day. The market does not anticipate, and thus does not incorporate the information of an increase in production; but rather adjusts during the post-announcement period.

Table 2.1: CARs around OPEC Increase quotas (whole period)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	-0.913	-0.992	-0.949	-0.407	0.9565	1.1106	0.4841	1.0095
-4	-1.37	-1.334	-1.42	-0.93	-0.878	-0.601	-0.87	-0.504
-3	-0.365	0.0397	-0.888	-0.214	0.9113	1.448	0.5565	1.2199
-2	-0.719	-0.927	-0.231	-0.652	-0.733	-0.453	0.2676	-0.207
-1	1.0415	0.4203	-0.111	0.0041	0.8405	0.7907	0.497	0.4353
0	1.604	-0.366	0.7762	-0.031	0.9324	0.3435	0.9122	0.3546
1	0.6312	-1.772*	-0.404	-1.678	-0.938	-1.71	-0.768	-1.881*
2	2.1016*	-0.537	0.9993	-0.078	0.3955	-0.467	0.5837	-0.514
3	-0.225	-2.637**	-1.299	-3.444***	-0.197	-1.136	-0.282	-1.594
4	-0.406	-1.621	-0.367	-2.872**	0.732	0.2859	0.945	-0.397
5	-1.959*	-3.852***	-0.765	-3.730***	-1.366	-2.261**	-0.254	-2.160**

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

Table 2.2: CARs around OPEC Increase quotas (1991 Q1–2004 Q3)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	-0.719	-0.913	-0.741	-0.204	0.4737	0.5135	0.2225	0.69
-4	-1.271	-1.165	-1.495	-0.673	-0.543	-0.305	-0.806	-0.276
-3	-0.292	0.2831	-1.237	0.2814	1.0548	1.5863	0.1915	1.36
-2	-0.995	-0.36	-1.039	0.0087	0.8139	1.3489	0.6476	1.2642
-1	1.459	1.0201	0.0922	1.2269	1.8642*	1.4807	0.9563	1.3376
0	1.8467*	0.1658	0.7074	0.8815	1.3438	0.3063	0.8701	0.5271
1	0.9359	-1.216	-0.698	-0.525	-0.555	-1.694	-1.13	-1.76
2	2.4645**	-0.331	0.9762	0.8002	0.6039	-0.994	0.1809	-0.93
3	0.0284	-2.532**	-0.927	-2.241**	0.8272	-0.873	0.1476	-1.198
4	-1.527	-1.960*	-0.117	-1.732	0.8742	0.1416	1.5471	-0.166
5	-1.024	-1.72	0.7509	-0.589	0.6401	-0.364	1.7889*	-0.095

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

Table 2.3: CARs around OPEC Increase quotas (2005 Q1–2015 Q1)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	0.0794	-0.095	0.3036	-0.05	-0.13	-0.169	0.056	-0.091
-4	0.1802	-0.18	0.2615	-0.338	-0.4	-0.481	-0.207	-0.472
-3	0.7919	-0.063	0.8787	-0.603	-0.012	-0.271	0.3144	-0.375
-2	0.5619	-0.374	0.8725	-0.6	-0.553	-0.78	-0.104	-0.729
-1	0.4515	-0.804	0.4323	-1.239	-0.948	-1.217	-0.655	-1.34
0	0.4625	-0.69	0.5297	-1.008	-1.447	-1.647	-1.03	-1.628
1	0.1341	-1.425	0.2585	-1.616	-1.24	-1.495	-0.837	-1.564
2	-0.146	-1.31	-0.316	-1.366	-1.328	-1.425	-1.05	-1.382
3	-0.926	-2.097	-2.197	-2.913*	-2.044	-2.049	-2.397*	-2.542*
4	-0.183	-1.703	-2.349	-3.532**	-2.947*	-3.070*	-3.565**	-3.906**
5	0.1275	-1.498	-1.341	-3.145*	-4.373**	-4.464**	-4.422**	-4.881**

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

As expected, the CARs are negative in most cases. Indeed, an increase in oil production will drive prices down. Nevertheless, Figure 2 reveals that CARs may be positive, although more often insignificant. This result is more pronounced during the first sub-period and for Brent oil prices. A possible explanation could be as follows. On the one hand, OPEC often acts as a marginal producer (see, for example, Kaufmann, 2004) in order to offset, at least partially, the difference between oil demand and non-OPEC supply, using its spare production

capacity<sup>19</sup>. Between 1991 and 2004, we observe two phenomena. First, the consumption of crude oil constantly increased, as did the production by both OPEC and non-OPEC producers. Second, the level of OPEC's spare capacity dramatically plummeted between 1981 (around 14 million barrels (mb) per day) and 1990 (less than 2mbper day), whereas it fluctuated during the first sub-period between about 2 mb per day and 8 mb per day. On the other hand, non-OPEC oil producers are generally considered as price takers, meaning that they do not adjust their production to influence oil prices. Consequently, non-OPEC producers operate at or near full capacity and so have little spare capacity. Taking all these considerations together, it can be argued that an increase in OPEC's production may be interpreted by market participants as a sign of tensions in the oil market, signaling a greater intervention of OPEC and thus resulting in higher future oil prices. The greater is the OPEC intervention, the greater is its impact on oil prices. However, OPEC's diminishing spare capacity limits its ability to manipulate oil prices.

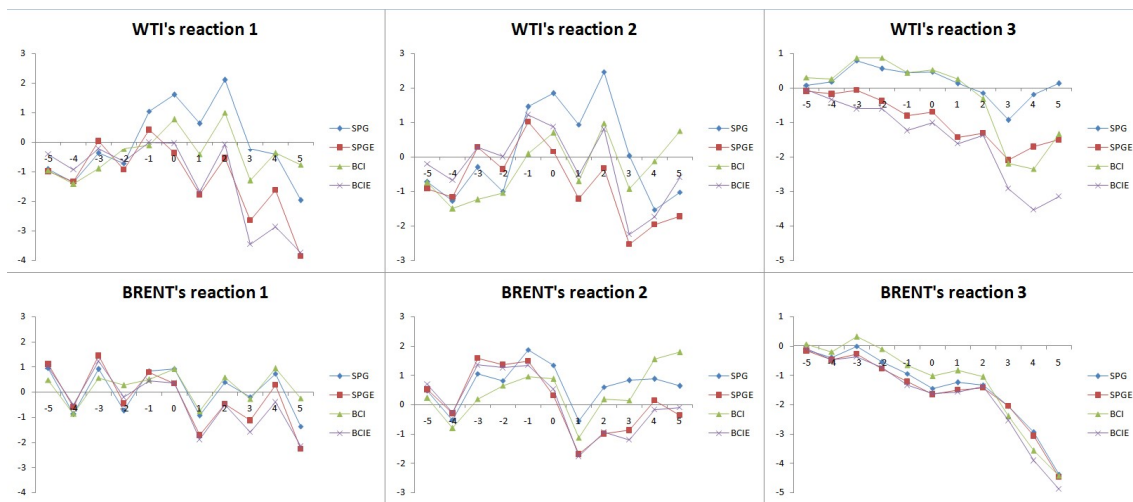


Fig.2.CAR paths for increase quota announcements for all periods.

When a reduction in oil production is announced, the results, consistently with other papers mentioned above, are more significant than in the previous case (see Tables 3 and Figure 3). In general, WTI prices react more than Brent prices to OPEC's cut announcements, whatever the index. Moreover, except for the second sub-period, the results seem more sensitive to S&P GSCI than to BCI. This can be explained by the weights of the WTI crude oil and Brent crude oil in these indices. Indeed, the weight of WTI crude oil is higher than that of Brent crude oil in

<sup>19</sup> The US Energy Information Administration (EIA) defines spare production capacity as the additional volume of production that can be brought on within 30 days and sustained for at least 90 days.

the two indices, even if, in recent years (notably since 2011), the proportion of WTI decreases in favor of Brent, though the latter has not overtaken the former yet. For example, the weight of WTI (Brent) in the S&P GSCI in 2011 and 2013 was 32.6% (15.9%) and 24.7% (22.1%), respectively. For BCI, the corresponding figures were 14.7% (0%) in 2011 and 9.2% (5.8%) in 2013. Moreover, the cumulated weights of WTI crude oil and of Brent crude oil in the S&P GSCI are much more important than those in the BCI. Similar to an increase in production quotas decisions, in most cases, the cut decisions have a significant effect after the announcement day. However, for the whole period and especially for the first sub-period, WTI returns responded significantly to those decisions before the announcement day (up to three days). It follows that when WTI prices fluctuate in a relatively narrow band, the market anticipates OPEC's cut decisions. The significance is more pronounced for the first sub-period when prices are lower.

Table 3.1: CARs around OPEC Cut quota (whole period)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	1.0654	2.1977**	0.5377	1.6423	-0.672	-0.178	-0.646	-0.066
-4	-0.077	1.1491	-1.084	0.1004	-1.108	-0.475	-1.357	-0.537
-3	1.0526	2.5101**	-1.421	0.4258	-0.992	-0.577	-1.832*	-0.8
-2	4.9594***	6.1881***	1.6233	3.6938***	-0.552	-0.309	-1.436	-0.726
-1	4.3605***	5.5061***	1.4622	3.6321***	-2.093*	-1.689	-2.393**	-1.761*
0	5.1300***	6.7901***	1.1624	4.7161***	-1.639	-0.816	-2.704**	-1.346
1	3.3274***	6.8082***	-1.636	3.7246***	-0.668	1.3256	-3.149***	0.008
2	5.0297***	7.7418***	0.7496	4.7708***	0.8996	2.3142**	-0.909	1.0924
3	5.2433***	6.9346***	1.7764*	4.5189***	-0.352	0.5913	-1.442	-0.614
4	8.9417***	11.097***	3.4826***	6.8278***	2.5129**	3.7759***	0.3182	1.6938
5	10.401***	11.149***	4.6224***	7.8437***	3.3224***	3.5812***	1.2033	2.3220**

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

Table 3.2: CARs around OPEC Cut quota (1991 Q1–2004 Q3)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	1.1696	2.3405**	1.0231	2.3437**	-1.047	-0.293	-0.591	0.0354
-4	0.2943	1.2829	-0.125	0.7477	-0.896	-0.201	-0.637	-0.064
-3	1.435	2.8281**	0.121	1.0971	-1.241	-0.712	-1.287	-0.936
-2	6.2649***	7.3916***	4.2263***	5.3905***	-0.675	-0.57	-0.732	-0.972
-1	5.4739***	6.8758***	3.9540***	5.4296***	-1.810*	-1.403	-1.142	-1.549
0	6.0893***	8.0768***	2.8182**	6.3392***	-1.492	-0.678	-2.371**	-1.317
1	4.1565***	6.7166***	-0.203	4.5528***	0.7964	2.4405**	-1.953*	0.7934
2	5.0791***	7.3433***	1.9694*	5.2204***	1.6459	2.8367**	-0.189	1.1326
3	5.8620***	7.8169***	3.1423***	5.5218***	0.6134	1.2789	-0.697	-0.585
4	8.2060***	10.345***	4.0904***	6.8369***	3.6584***	4.4177***	0.8935	1.4791
5	8.9883***	9.6376***	5.1893***	7.1206***	4.6163***	4.0663***	2.1016*	1.9039*

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

Table 3.3: CARs around OPEC Increase quota (2005 Q1–2015 Q1)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	-0.024	0.1417	-0.451	-0.735	-0.023	0.0694	-0.289	-0.266
-4	-1	-1.028	-1.017	-1.48	-0.59	-0.387	-0.674	-0.568
-3	-0.805	-1.96	-2.091	-2.087	0.0126	0.073	-0.651	-0.316
-2	-1.947	-3.050*	-2.525*	-3.120*	-0.164	0.0123	-0.801	-0.601
-1	-2.249	-4.089**	-2.34	-3.917**	-1.611	-1.469	-1.985	-1.889
0	-2.627*	-4.562**	-2.718*	-4.405**	-1.292	-1.139	-1.76	-1.677
1	-1.475	-3.214**	-2.109	-3.452**	-2.317	-2.065	-2.711*	-2.409*
2	-0.743	-2.361*	-1.91	-2.961*	-1.336	-1.104	-1.85	-1.547
3	-1.067	-3.086*	-1.267	-3.170*	-1.636	-1.498	-1.701	-1.67
4	1.9862	-0.075	0.1041	-1.395	-0.414	-0.254	-0.854	-0.622
5	2.3457	0.4086	-0.086	-1.193	-1.17	-0.909	-1.761	-1.221

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

Following a cut in production, oil prices should increase and consequently CARs should be positive. This is indeed the case for the whole period and the first sub-period for both WTI and Brent crude oils. However, during the second sub-period, significant CARs are negative and high for the two crude oil prices (see also Guidi et al., 2006; Lin and Tamvakis, 2010). Despite the OPEC cut announcement, oil prices have continued to decrease. OPEC's cut decisions occurred in 2006, when oil prices fell significantly, and before the sharp increases in 2007 and 2008 (when prices peaked in July 2008). This apparently counterintuitive result may reflect considerations of market participants with regard to world current and future supply and demand for oil and their skepticism concerning the

cohesion of OPEC as a group, as well as the actual reduction in production. Indeed, from 2005 to 2008, economic growth and oil demand were strong, whereas the oil supply and the spare capacity were low, putting upward pressure on oil prices.

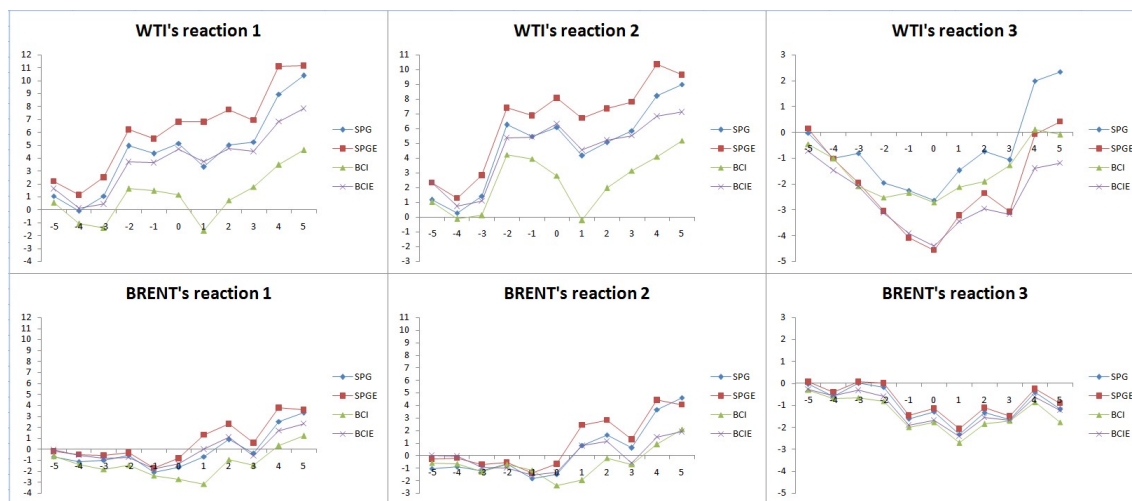


Fig.3. CAR paths for Cut quota announcements for all periods.

However, oil prices depend also on expectations of future supply and demand, which turn out to be very difficult to predict when market conditions are uncertain. For instance, a slight discrepancy between EIA's oil demand forecasts and anticipations for 2007 impacted oil prices more heavily than OPEC's announcement. In 2008, market participants attached more importance to the world economic recession and the resulting decrease in oil demand than to the insufficient OPEC production cut. Economic considerations may be amplified by OPEC members' behavior vis-à-vis quotas. OPEC is a group of countries with divergent political and economic interests. Its members may disagree on the decision and on the level of quota cuts, in particular during periods when prices are falling. In this case, it is difficult to achieve discipline on the part of OPEC members, who may not comply with the quotas assigned (as experienced in 2015 by the actions of a key member, Saudi Arabia).

Tables 4 and Figure 4 present the results when production quotas remain unchanged. The most significant results are obtained for this decision type. There are more significant CARs for WTI than for Brent (see also Mensi et al., 2014) and relative to BCI. In almost all cases, the sign of the CARs is negative. Status quo decisions may have a significant impact on the pre-announcement period, on the event day, and on the post-announcement window. Such announcements are often perceived as non-decisions for different reasons, as already mentioned

above. Market fundamentals, economic conditions, or geopolitical events could lead OPEC to reduce its production. Nevertheless, disagreements among OPEC members result in a status quo. The market interprets such decisions as a signal that there is a sufficient level of supply. Thus oil prices fall and CARs are negative. Moreover, it recognizes a greater influence of these decisions and tries to anticipate them. A maintain of production also has an influence on returns with a post-announcement delay of several days, notably in the second sub-period and for WTI prices.

Table 4.1: CARs around OPEC Maintain quota (whole period)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	0.6244	0.2873	-0.01	1.3581	0.8959	1.097	0.4101	1.1929
-4	-0.336	-0.38	-1.273	0.8522	-1.243	-0.825	-1.688*	-0.59
-3	-1.756*	-1.478	-4.369***	-0.013	-0.983	-0.169	-2.835***	-0.23
-2	-0.427	-0.775	-3.255***	0.1787	-0.528	0.07	-2.035**	-0.281
-1	-0.5	-1.272	-2.501**	0.0516	0.114	0.397	-0.802	0.2143
0	-2.142**	-3.466***	-3.696***	-2.241**	-2.534**	-2.691***	-2.937***	-2.862***
1	-2.194**	-2.998***	-3.210***	-0.899	-0.665	-0.743	-1.052	-0.858
2	-2.141**	-3.123***	-3.424***	-1.361	-1.58	-1.929*	-1.851*	-2.247**
3	0.5983	0.925	-1.381	2.6197**	-0.75	-0.416	-1.211	-0.36
4	2.0875**	2.0416**	-0.599	3.2914***	-1.089	-1.117	-1.315	-0.79
5	1.8057*	1.512	-1.024	3.0351***	-1.143	-1.221	-1.257	-0.825

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

Table 4.2: CARs around OPEC Maintain quota (1991 Q1–2004 Q3)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	1.8813*	1.5666	1.4135	1.8844*	1.3548	1.1696	0.9787	1.0709
-4	1.0096	0.7638	1.0563	1.4955	-0.195	-0.22	-0.13	-0.264
-3	-0.604	-0.839	-2.115**	0.0385	-0.823	-0.511	-2.345**	-0.896
-2	-0.502	-0.611	-1.876*	-0.223	-0.393	-0.092	-1.872*	-0.932
-1	-0.977	-0.62	-1.907*	-0.338	-0.119	0.3904	-1.147	-0.63
0	-2.956***	-3.021***	-3.752***	-2.719**	-1.749*	-1.791*	-2.743**	-3.190***
1	-2.186**	-2.086**	-2.692**	-1.482	-0.349	-0.327	-1.439	-1.894*
2	-0.982	-1.144	-1.444	-0.711	-0.75	-1.355	-1.544	-3.221***
3	2.0383*	3.3738***	0.8984	3.9668***	0.105	0.2595	-1.254	-1.053
4	2.4515**	3.3606***	1.0578	3.6297***	0.0327	-0.334	-1.409	-1.783*
5	1.6371	2.4483**	0.228	2.6271**	-0.148	-0.617	-1.763*	-2.108**

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.



Table 4.3: CARs around OPEC Maintain quota (2005 Q1–2015 Q1)

Event Day	WTI				BRENT			
	SPG	SPGE	BCI	BCIE	SPG	SPGE	BCI	BCIE
-5	-1.167	-1.727*	-1.553	-0.407	0.1121	0.4306	-0.28	0.4509
-4	-1.656	-2.200**	-2.904***	-0.855	-1.374	-0.827	-1.942*	-0.565
-3	-1.950*	-2.692**	-4.128***	-0.969	-0.385	0.3276	-1.587	0.4366
-2	-0.116	-2.042*	-2.747**	-0.642	-0.101	0.2984	-1.018	0.501
-1	0.1564	-3.163***	-1.824*	-1.147	0.1359	0.1649	-0.326	0.667
0	-0.048	-4.578***	-1.422	-2.333**	-1.551	-1.746*	-1.389	-0.816
1	-1.064	-5.340***	-1.997*	-2.148**	-0.334	-0.463	0.0299	0.7894
2	-2.527**	-6.746***	-3.756***	-3.968***	-1.313	-1.21	-1.031	0.0523
3	-1.513	-5.455***	-2.960***	-3.220***	-0.703	-0.496	-0.328	0.7813
4	0.285	-4.013***	-1.903*	-2.055*	-0.859	-0.746	-0.226	1.0524
5	0.621	-3.959***	-1.612	-1.577	-0.592	-0.51	0.2011	1.4665

Note: \*/\*\*/\*\* indicates the t-statistic is significant at 10%/5%/1% level respectively. The following acronyms are used. WTI: West Texas Intermediate, SPG: Standard and Poors Commodity Index, BCI: Bloomberg Commodity Index, SPGE and BCIE are their energy counterparts.

These results may be put in perspective by introducing non-conventional oil resources into the reasoning. The exploration of such resources is relatively costly and is economically efficient only under high oil price conditions. For instance, the US produced more than 3 mb a day in 2014 from shale formations. If prices remain high, non-OPEC countries can raise their production and challenge OPEC’s role in oil price formation. However, OPEC members’ exports and revenues depend heavily on oil prices. Thus, OPEC faces a dilemma: maintain production quotas at levels that would keep prices elevated or at levels that would contribute to lower prices, forcing out some of the high-cost producers. The potential increase in non-conventional oil resources and natural gas production, which can significantly affect global energy markets, may arise as a key factor in OPEC’s decision-making.

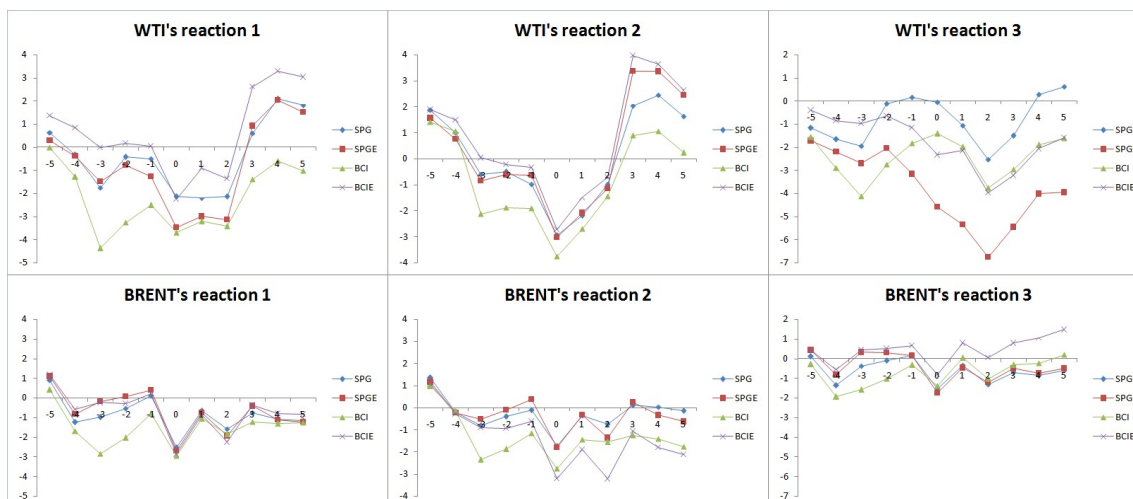


Fig.4. CAR paths for Maintain quota announcements for all periods.

#### **4. Conclusion and Policy Implications**

The aim of this paper is to contribute to the existing literature on the OPEC role as a major player in oil markets through the impact of its production quotas announcements on oil prices during the period 1991-June 2013. We use the event study methodology and measure abnormal returns and volatility by the market model and the EGARCH model respectively. We opt for this last to capture some well-known stylized facts characterizing volatility, which differentiates our paper from a few other papers utilizing a GARCH model. To enrich the analysis and for robustness purposes, we examine the impact of OPEC decisions on both WTI and Brent daily returns and use two indices as proxies for the market portfolio (BCI and S&P GSCI).

We find that the announcements effect on oil prices varies across periods, production decisions, oil prices and benchmark indices. Our results suggest that OPEC is less influential during periods when oil prices are high the more so as above a certain level price, unconventional oil resources are economically viable. However, although the effect of OPEC decisions is more pronounced when prices are low, OPEC members may face a dilemma: keeping prices at low levels could prevent high cost oil producers from entering the market, but, at the same time, could reduce OPEC members' revenues. Oil prices respond differently to quotas changes: a reduction or a status quo in production results in significant cumulative abnormal returns in contrast to an increase in production. These decisions reflect disagreements or a lack of discipline among OPEC's members and the necessity for OPEC to take into account previous unilateral quotas changes. More specifically, a cut decision has a stronger effect and is anticipated by the market when price fluctuations are lower. These reactions may also diverge in significance and magnitude for WTI and Brent crude oil. Similarly, the use of a different index (S&P GSCI or BCI) may alter the results as a consequence of the importance of oil prices in the composition of the index.

# Chapitre 2

## OPEC production announcements: Effects on stock prices

### 1. Introduction

Following the early 1970s oil prices' shocks and their consequences on western economies, several studies as the seminal work of Hamilton (1983) concluded that oil prices changes are influential in predicting stock markets movements. On another note, the Organization of Petroleum Exporting Countries (OPEC) accounts for 40% of the produced oil in the world and for 60% of the exported oil internationally (see EIA and Matsumoto et al. (2012)). The impact of OPEC's production quota announcements (namely increase, cut or maintain production quotas) on oil prices has been subject to debate among researchers, policy makers and regulators. Some argue this impact to be weak or declining over time as more non-OPEC members increase their market shares and new sources of non-conventional oil are being exploited ( US shale oil, Canada's tar sands or Brazil's deep sea offshore oil to cite some). Others support the idea that this impact is time varying depending on the prevailing market conditions. Therefore, OPEC's production quota announcements seem to have an impact on stock markets through oil prices.

The purpose of this paper is to investigate the informational role of OPEC and its (potential) contribution to stock prices formation. Our aim is to evaluate the impact of OPEC announcements, through the event study methodology (see, for instance MacKinlay, 1997), on stock market prices, which are characterized by a time-varying volatility.

The importance of oil as an energy source for all economies doesn't need any proof. However, the influence of oil prices on stock markets is more controversial. The impact of oil prices on stock markets have been analyzed through the market structure (see for instance, Hamilton, 1983), Hamilton, 2008), Cai et al., 2017, Ramos and Veiga, 2013). Some conclude this impact to be significant (see Rafailidis and Katrakilidis, 2014, Malik and Hammoudeh, 2017, Ponka, 2016 and Chen and Lv, 2015 among others) with conflicting directions for the relationship between oil prices and stock prices. A second subset argues oil prices to be positive for most of

the mixed results are reported for studies involving economic sectors. Some others failed to establish a significant evidence of oil prices effect on stock markets. (See Fang and You, 2014, Leatham and Wu, 2014 and Als Salman, 2016).

More recent studies have been conducted on the same topic and proposed a new paradigm. In particular, Killian and Park (2009) decomposed oil prices shocks into three categories: supply shocks, demand shocks and precautionary demand shocks. This decomposition allowed the authors to find that only demand and precautionary shocks yielded a significant impact on stocks. Furthermore, they argue that demand shocks have a positive impact on stocks as they signal a potential global growth in the global economies. Therefore, the added incurred costs from oil are fully absorbed by the growth. On the other hand, they argue that precautionary demand (a demand specific to developing countries only such as China or India) impacts the stocks prices negatively as the growth is not shared by all market participants and resulted in added incurred costs. Other studies (see Apergis and Miller, 2009, for instance) use the same paradigm and find oil supply shocks, aggregate demand shocks and oil idiosyncratic shocks to be significant in explaining stock returns.

OPEC is a major provider of oil (60% of the exported oil internationally) and its potential impact on oil prices has been analyzed, through the market structure, in the literature (Bina and Minh, 2007, Fattouh and Mahadeva, 2013). Models often consider OPEC as a cartel, whose members can collude, manipulating prices through production quotas, resulting in monopolistic profits (see, among others, Ezzati, 1976, Pindyck, 1978, Adelman, 1980, Adelman, 1982, Salant, 1982, Aperjis, 1982, Griffin, 1985 and Smith, 2005). An alternative view is based on market competition, suggesting that the oil market is competitive and therefore OPEC has little influence on oil prices by operating as a cartel (Crémer and Salehi-Isfahani, 1980, Crémer and Salehi-Isfahani, 1989, MacAvoy, 1982 and Teece, 1982). Empirical evidence for these two explanations of OPEC behavior has yielded conflicting results (see, for instance, Loderer, 1985, Griffin, 1985, Gulen, 1996, Alhajji and Huettner, 2000, Kaufmann et al., 2004 and Smith, 2005). Geroski et al., 1987, Griffin and Neilson, 1994, Brémond et al., 2012 and Fattouh and Mahadeva, 2013 argue that OPEC's behavior varies over time depending on economic, market, and geopolitical conditions and cannot be represented by a single model.

Few papers deal with the OPEC announcements and even fewer employ the event study methodology. Hyndman (2008) studied how crude oil spot and two-month futures prices, as well as prices of oil-related company stocks, reacted to OPEC's announcements during 1986–2002. His results indicate that abnormal returns are statistically significant. However, he did not specify the model that allowed him to calculate abnormal returns. Lin and Tamvakis (2010) enriched the analysis over a long period, 1982–2008, by examining the impact of OPEC's announcements on OPEC and non-OPEC crude oil, and for different oil qualities. Their empirical evidence suggests that the effect of OPEC's decision depends on the production quotas (increase, cut, or status quo) and on the price trend. In contrast, they did not find a significant difference between OPEC and non-OPEC crudes or between oil qualities. The computation of abnormal returns is not based on any model, but rather on the average daily return of the estimation period. Loutia et al. (2016), found the impact to be varying over time, to be dependent on the production decisions and to be related to the oil basket used. Furthermore, they found OPEC to be the least influential when prices are the highest as unconventional oil producers seem to thrive under these conditions.

Even though, the literature has largely investigated the effect of oil prices on stock markets and has equally investigated the link between OPEC's quota announcements on oil prices, few papers analyzed directly the effect of such announcements on stock markets. To the best of our knowledge, only the studies of Guidi et al. (2006) and Gupta and Banerjee (2019) tackle the impact of OPEC announcements on stock markets. First, in Guidi et al. (2006), the authors argue that OPEC's decisions are more influential during conflict periods on UK and US stocks. Furthermore, only the cut decisions seem to have a significantly positive impact on US stock prices and a significantly negative impact on UK prices. In Gupta and Banerjee (2019), the authors used the news sentiment framework to analyze the impact of OPEC news sentiment on the US listed energy firms. They conclude that the effect is conditional on the market's risk state and the types of news that negatively viewed news on OPEC have a positive impact and are stronger during periods of higher reserves, exports and production and that positively viewed news on OPEC to be significant in periods of low consumer confidence and high imports.

The purpose of this paper is to investigate the impact of OPEC's quota decisions on stock markets in a framework of event studies. Our dataset covers the period from February 1991 to July 2015, including the sharp fluctuations in oil prices of 2008 (a sharp increase followed by an important decrease before another pronounced increase), characterized by a high level of volatility. We divide the period into two sub-periods (1991–2004 and 2005–2015): during the first sub-period, oil prices uniformly increased, while the second sub-period was much more turbulent and oil prices were much higher. This allows us both to examine if stock prices reacted distinctly to OPEC's announcements during these two periods and to assess the robustness of our results. We consider daily returns of 479 listed companies, in-sample computed sector portfolio's returns and OPEC's announcements of drop, status quo, or increase oil production. To compute abnormal returns, we use a 3 factor Fama-French model with in-sample computed HML and SMB and the residuals modeled by an Exponential GARCH (EGARCH) process, developed by Nelson (1990), in order to capture the random volatility of stock prices. To the best of our knowledge, in the event studies setting applied to OPEC's announcements, Bina and Vo (2007) and Loutia et al. (2016) have been the only ones to date to use GARCH residuals. However, two stylized facts characterize the volatility behavior of asset prices: first, the existence of an asymmetric response of volatility to positive and negative past returns and, second, the persistence of shocks for the estimates of volatility (see Narayan and Narayan, 2007, Ewing and Malik, 2010 and Wei et al., 2010). The EGARCH model is able to represent these observed properties. For the empirical tests, as a proxy for the market portfolio, we use three different popular portfolio indices, the Standard & Poor's Global 1200 Index (SPGLOB), the MSCI World Index (MXWD) and the MSCI ACWI Index (MXWO). Thus we are able to assess the sensitivity of our results to different indices and to complement the existing literature.

We find that the announcements effect on stocks varies across periods, production decisions, industries and benchmark indices. Our results indicate OPEC to be the most influential in the second sub period where oil prices have known sharp fluctuations. Industries seem to be reactive to either increase or cut decisions rather than maintain decisions. Moreover, increase decisions seem to be the most effective. The results show the reaction to be more pronounced when S&P Global 1200 is employed and the reactions to be dependent on industry idiosyncratic features.

The remainder of the paper is organized as follows. The data and methodology are described in Section 2. Section 3 presents and discusses our empirical findings. Finally, Section 4 offers some concluding remarks and the policy implications of our findings.

## **2. Data and methodology**

In this section, we first describe the data used before going briefly through the event study methodology using a 3 factor Fama-French model.

### **2.1 Data description**

The data consists of daily returns of 479 companies related to 57 industries from Bloomberg's database and covering the period from January 1991 to July 2015. During the same time span, we can distinguish two distinct evolutions for oil prices. The first evolution can be spotted from 1991 to 2004 where oil's price was slowly but steadily increasing while the second period is more volatile and goes from 2005 to 2015. In fact, the steady increase has morphed into a sharp increase where oil prices have breached the 100\$ limit on 2008 before dwindling to as much as around 30\$ in less than 6 months (80% loss of value). Within the same period, oil prices have seen similar development. Therefore, we can conclude to the differences in volatility levels between the two periods. To factor in these differences, three panels, out of our sample, were constructed: a panel A for the whole period (8977 daily observations), a panel B from January 1991 to December 2004 (5114 daily observations), and a panel C from January 2005 to July 2015 (3863 daily observations).

Regarding the benchmarks we employ, we have selected the Standard & Poors Global 1200 (S&P Global 1200), Morgan Stanley Capital International All Country World Index (MSCI ACWI) and Morgan Stanley Capital International World (MSCI World). First, the S&P Global 1200 is a broadly diversified index, highly liquid and covers 31 countries and about 70% of the global stock markets capitalization. Second, the MSCI ACWI is a broadly diversified index (23 Developed Markets and 24 Emerging Markets countries) and captures approximately 85% of the global investable equity through its 2771 constituents. Finally, the MSCI World Index is less diversified than the previous ones (23 Developed Markets with no emergent country in the mix) and captures approximately 85% through its 1635 constituents. Besides, all the presented indexes encompass all the industries as defined by the Global Industry Classification Standard (GICS).

OPEC decisions on oil production are made during OPEC conferences, which take place at least twice a year. In addition to these regular meetings, if market conditions require extraordinary meetings can be held during the year. The decisions may take the form of quota reductions, increases, or maintenance of the status quo. A formal announcement is made at the end of each conference with the cartel's decision. In our methodology, these announcements are considered as the event day.

## 2.2 The methodology

To investigate the effects of OPEC announcements on stock prices, we use an event study methodology. It has widely been applied to many fields in financial economics especially to stock markets but less frequently to OPEC decisions. Event studies examine the behavior of abnormal returns of a security around a relevant event. In our case, events are announcements made by OPEC about its oil production output. The incorporation of the information, following an event, in asset prices may be immediate or may spread out over time. The choice of the event window is not based on formal rules and can differ among different studies. We opt for an event window of five days before and after the announcement (see also Horan et al., 2004 and Bina and Vo, 2007). This choice is based on several concerns: to capture information leakages before the OPEC announcement, to take into account the reaction of stock prices after the announcement, to prevent overlapping among OPEC meetings (in the case of extraordinary meetings), and to avoid contamination from other events. The assessment of the event's impact on asset prices can be measured by the abnormal return ( $AR_t$ ), which is defined as follows:

$$AR_t = R_t - E(R_t) \quad (1)$$

where  $R_t$  is the daily log return on crude oil at date  $t$  and  $E(R_t)$  is the normal return, which is the expected log return at date  $t$  over a period other than the event window. This expectation is not conditional on the information related to the event. Abnormal returns are used to compute cumulative abnormal returns (CARs) as the sum of the daily abnormal returns over the event window:

$$CAR_t = \sum_{t=-5}^{+5} AR_t \quad (2)$$



The normal returns can be estimated (see also MacKinlay, 1997) by the market model or factor models (Draper, 1984; Demirer and Kutan, 2010), by autoregressive models (Bina and Vo, 2007), or by the constant mean return model (Guidi et al., 2006; Lin and Tamvakis, 2010). In this paper, we use a Fama French 3-factor model. We construct the SMB (Small minus Big) and HML (High minus Low) ratios following the methodology in Fama and French (1993). The companies are sorted independently twice, a first time according to their market capitalization and a second time according to their B/M ratio (Book to Market ratio). Following the first sorting, we divide the companies into two groups: above median companies are referred to as Big (B), below median companies are referred to as Small (S). The same companies are sorted according to their B/M. The companies in the 70<sup>th</sup> percentile are placed in the High (H) group, those below the 30<sup>th</sup> percentile are placed in the Low (L) Group and the remainder is placed in the Medium (M) group. This procedure results in six portfolios of roughly the same amount of stocks. In our case, we turn to the daily returns of these stocks to compute the FAMA-FRENCH factors according to the formulas in (3). To construct the sectors series, we select the firms belonging to each sector and make an average. The following analysis will be about sectors only. The strong assumption of homoskedasticity in stock price time-series is relaxed in some papers in which the variance of residuals follows an ARCH process (Deaves and Krinsky, 1992; Demirer and Kutan, 2010) or a GARCH process (Bina and Vo, 2007). Indeed, high price volatility is a feature of stock markets, and there is strong evidence supporting heteroscedasticity in stocks (see, among others, Morana, 2001, Narayan and Narayan, 2007 and Mohammadi and Su, 2010). In this paper, the normal returns are measured by two equations: the 3 factor Fama-French with homoskedastic residuals (4) and the 3 factor French Model with EGARCH residuals to capture asymmetric variance effects (5).

$$SMB = \frac{(r_{S/L} - r_{B/L}) + (r_{S/M} - r_{B/M}) + (r_{S/H} - r_{B/H})}{3} \quad (3)$$

$$HML = \frac{(r_{S/H} - r_{S/L}) + (r_{B/H} - r_{B/L})}{2}$$

$$R_{it} = \alpha + \beta_1 R_{mt} + \beta_2 (SMB_t) + \beta_3 (HML_t) + \epsilon_t \quad (4)$$

$$E(\epsilon_t) = 0 \text{ and } Var(\epsilon_t) = h_t^2$$

$$\log(h_t) = \omega + \sum_{i=1}^p a_i \log(h_{t-i}) + \sum_{j=1}^q b_j \left( \left| \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} - \sqrt{\frac{2}{\pi}} \right| + \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} \right) \quad (5)$$

Where  $R_t$  and  $R_{mt}$  are the returns at date  $t$  on stock returns, the market portfolio, the SMB (Small Minus Big) ratio and the HML ratio (High Minus Low), respectively, and  $\varepsilon_t$  is the disturbance term.  $\alpha$ ,  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$  are the parameters of the market model, and are constants.  $h_t$  is the volatility term,  $\omega$  is the constant, where  $a_i$  and  $b_i$  are the weights of the lagged log volatilities and the corrective terms of the models, respectively.

The EGARCH model has some advantages compared to the GARCH model and incorporates some features in stock price volatility. First, unlike the GARCH model, it does not require the imposition of non-negative constraints on the parameters  $\alpha$ ,  $\beta$ , and  $\gamma$ , since the variance is automatically constrained to be positive, as the conditional variance is specified in the logarithmic form. Second, it accounts for an asymmetric reaction of volatility to a shock observed in many financial series, which is captured by the parameter  $\gamma$ . A positive parameter implies that a positive shock results in a higher future conditional volatility than a negative shock of the same magnitude and vice versa. Third, the EGARCH model is stationary if  $\alpha < 1$ . The persistence of a shock can be assessed through the estimate of the latter parameter (see Narayan and Narayan, 2007). For the market portfolio, as a market-wide index, we use three different stock indices, S&P Global 1200, MSCI World, and MSCI ACWI, all widely accepted by investors. Using these three indexes allows us to test the dependence of the results on the choice of the index. Once the abnormal returns have been obtained, we perform significance tests on the effect of OPEC's three decisions on oil prices. The null hypothesis indicates that these decisions have no impact on stock prices. In other words, we test whether  $AR_t$  and  $CAR_t$  are significantly different from zero for each day within the event window. We make use of the cross-sectional parametric test suggested by Corrado (2011), Bina and Vo (2007), and Savickas (2003), which addresses both the conditionally heteroscedastic behavior of volatility and the event-induced variance changes. The t-statistic is formulated as follows:

$$Test = \frac{SCAR_{it}}{\sigma_{SE}} \quad (6)$$

$$\text{Where } SCAR_{it} = \frac{\sum_{-5}^{+5} AR_{it}}{\sqrt{\hat{h}_{it}}} \quad (7)$$

After the choice of the normal model, the final step is to determine the estimation period. Although there is no procedure for the definition of this period, usually a pre-event window period is used to avoid the impact of the event on the estimation of the parameters of the normal model. In this paper, the estimation period is obtained by removing the event windows from the initial samples and aggregating the obtained series. This procedure allows us to capture more events.

### 3. Empirical results and discussion

In this section, we present and discuss our main results for the companies and sectors under scrutiny, for each index, each OPEC decision and each sub-period considered. The below show the CARs and the paths for an increase quota decision for some representative industries.

Following a maintain announcement, we found no significant reaction for the whole period and some significant results for the two sub periods considered. All the reactions occur when the S&P Global 1200 is used as proxy. One explanation for the low significance could be that maintain decisions are considered as non decisions by financial markets. Market fundamentals, economic conditions, or geopolitical events could lead OPEC to reduce or increase its production. Nevertheless, disagreements among OPEC members result in a status quo. Therefore, the market participants might not give credit to this kind of decisions.

Another line of explanation could be related to the development of unconventional oil. The exploration of such resources is relatively costly and is economically efficient only under high oil price conditions. For instance, the US produced more than 3 mb a day in 2014 from shale formations. If prices remain high, non-OPEC countries can raise their production and challenge OPEC's role in oil price formation. However, OPEC members' exports and revenues depend heavily on oil prices. Thus, OPEC faces a dilemma: maintain production quotas at levels that would keep prices elevated or at levels that would contribute to lower prices, forcing out some of the high-cost producers. The potential increase in non-conventional oil resources and natural gas production, which can significantly affect global energy markets, may arise as a key factor in OPEC's decision-making. Therefore, the markets could be anticipating this state resulting in no statistically significant reactions.

During the first sub period, most of the signs are negative while during the second sub period, most signs become positive. This shift in signs is indicative of two phenomena. In the first sub period, OPEC is closely monitored as it is the biggest marginal player in the oil market. Therefore, a maintain decision can indicate in future supply of oil following potential indecisions from OPEC's side. As a result, managing the costs of energy can be challenging. In the second sub period, the oil market has undergone a major shift through the introduction of unconventional oil. As above-mentioned, OPEC's maintain decisions might be the reflection of a dilemma while finding the right supply to neither decrease its revenues beyond a critical point nor increase the same revenues permitting entry to new actors. For industries, maintain decisions might be interpreted as unspoken increasedecisions.

In the event of OPEC's cut decisions, the results are more significant than the previous ones. In most cases, the reaction is significant when the S&P 1200 Global is used as proxy except in the second sub period where the MSCI ACWI is alsoreactive.

Following a cut in production, CARs should be negative for most industries. In effect, cutting oil supply should drive oil prices upward putting pressure on businesses through increased costs of operation. This is the case for industries such as Aerospace & Defense, Airlines or Road & Rail for which energy is the main operating cost. Some industries have an opposite reaction due to the nature of their businesses. Oil and Gas and consumables industry is a prime example as its CARs is positive. The explanation may be twofold. On the one hand, one can argue that the rise of oil price levels is profitable to these companies as they supply in return refined oil products at higher prices increasing their margins. Therefore, a cut announcement is likely to signal this state of business. On the other hand, the higher the oil price levels get, the more profitable it becomes to exploit non conventional oil sources. Therefore, acut announcement could be interpreted as a greater likelihood to increase profits stemming from these non conventional oil sources.

Some industries' specificities can explain the unexpected results they show. This is the case for both IT services and water utilities. In the case of IT services in the event of a cut decision, one would expect the demand for such services to decline as a result of increased operational costs. However, while this is the case following a surge in oil prices, this industry provides companies with services that would be too costly if done in house. In

the case of water utilities, investors seem to massively invest in it as a hedging strategy against surging oil prices in a effort to diversify the energy mix and reduce the reliance on crude oilprices.

When an increase in quota productions is announced, the results are the most significant. In most cases, the results are significant when the S&P 1200 Global is employed except in the second sub period where the MSCI ACWI is also reactive. These results can be explained by OPEC's so-called "cheating" behavior—showing no respect for the quotas allocated to OPEC's members—with the tendency to increase their production above the agreed quotas (Kaufmann et al., 2004; Lin and Tamvakis, 2010; Colgan et al., 2012). For example, Colgan et al. (2012) has reported a 10% excess in production over OPEC members' quota from 1982 to 2009. OPEC may thus anticipate "cheating" by its members and adapt quotas accordingly. More generally, OPEC may endorse unilateral decisions made previously by its members. As result, companies may view it as a signal for a steady supply in the market. Therefore, companies can easily control for their costs of energy, at least in the short run. Another argument is put forward by Hyndman (2008). He explains that it is easier for OPEC's members to agree on a quota increase. A result that reinforces the steady supply line of thought as no potential political tensions between members is foreseen.

In this case, the CARs should be positive for most industries. In effect, an increase in OPEC's production quotas should increase the supply of oil which in turn lowers the prices. Following a cost to benefits framework, one can conclude that the firms' profits should increase as a result. To our surprise, most of the reactions are negative especially in the second sub period. Some industries such as airlines, electric utilities or gas utilities react positively as expected as energy is a big part of these businesses. In the case of airlines, lower costs of operating reflect directly on the prices seats are sold. In this competitive industry, this is a valuable edge<sup>20</sup>. In the same line of thought, gas and electricity distribution industries can lower their prices as a result of lowered operation costs. A possible general explanation for the prevalence of negative CARs could be the sharp fluctuations in oil prices during the second sub period. During this particular period, oil prices went from as high as 147\$ in July 2008 to as down as 32\$ in the following December. In this particular context, increase decisions

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<sup>20</sup> Source: MarketLine Airlines Industry profile, report of May 2015

may seem to the markets as a sign of instability<sup>21</sup>.

Some sectors' behavior, such as automobile and machinery, can be explained by evoking their characteristics. Indeed, energy is a major cost that can amount to 1/3 of total costs in the case of machinery<sup>22</sup>. A possible explanation resides in the weakening demand resulting from volatile oil prices on the one hand and from the aftermath of the crisis of 2008 on the other hand. Moreover, the rise of environmental concerns may have played a big role in the weakening of western consumption of cars.

Some industries deserve a more in depth look to understand their reactions to OPEC decisions. Some industries have systematically unexpected reactions to both cut and increase decisions especially in the second sub period. This is the case for both the Food Products and Tobacco industries. For both these industries, we expect an OPEC cut decision to be detrimental as it adds to the operation costs and an OPEC increase decision to have the opposite effect. An explanation would be the emergence of biofuels as a substitute to conventional crude oil. In the event of a cut decision, crude oil prices soar increasing the production of more biofuel. Consequently, more food products and tobacco are converted into this new fuel bolstering the margins. Conversely, an increase decision damages the margins as biofuels decline as a viable substitute to crude oil.

#### **4. Conclusion**

The purpose of this paper is to investigate the impact of OPEC's quota decisions on stock markets under the framework of event studies. We cover the period stretching from January 1991 to July 2015 and we consider 56 industries from the GICS classification system. For robustness purposes, we consider three market proxies: S&P Global 1200, MSCI ACWI AND MSCI Global indexes.

An extension to the present study would be the use the market's sentiment data. In this framework, we can capture the market's reaction to each announcement. As customary, news are labelled as "good", "bad" or "neutral". This framework is best showcased in Hervé et al. (2019).

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<sup>21</sup> Source: MarketLine Aerospace and Defense Industry profile, report of July 2015

<sup>22</sup> Source: MarketLine Machinery Industry profile, report of 2015

# Chapitre3

## Co-movements of commodity indexes: Is financialization a fact or a fantasy?

### 1. Introduction

Following the 2000s stock market crisis, investors turned to commodities in an effort to diversify their portfolios and to generate more revenues as well. This rush to commodities has been justified by two papers, in particular, Erb and Harvey (2006) and Gorton and Rouwenhorst (2006) that emphasize the ability of commodities to generate equity-like revenues in the long term and act as a diversifier for portfolios especially when the correlations between commodities and stocks as well as the correlations in between commodity categories are thought to be very low. In recent studies, however, researchers have found index commodities to be more correlated with stocks and different categories of commodities seemingly unrelated in a fundamental level (see for instance Miffre, 2012, Tang and Xiong, 2012, Buyuksahin and Robe, 2013, Silvennoinen and Thorp, 2013).

As commodities gained a great attention, the commodity markets got billions of investment dollars from financial institutions, insurance companies, pension funds, foundations, hedge funds, and wealthy individuals (Wang et al., 2015; Mi et al., 2017). The initial success triggered more inflows of money from institutional funds referred to as “the financialization of commodities” attributed to the emergence of commodities as an asset class (see for instance, Basak and Pavlova, 2016).

A consequence of commodities’ financialization is an effect of this massive inflow of investments to the volatility of commodities, their correlation with financial assets as well as the correlation among commodities. Indeed, Tang and Xiong (2012) and Adams and Glück (2015) have argued that the rebalancing of portfolios by index investors may have led to spillovers of volatility between traditional financial and commodity markets. Furthermore, it was reported that commodities price levels substantially changed especially after the burst of the 2000 bubble (Miffre, 2012; Tang and Xiong, 2012; Buyuksahin and Robe, 2013). However, although correlations are subject to changes over time (see, for instance, Silvennoinen and Thorp, 2013), to the best of our knowledge, few papers use the asymmetric conditional correlations (see Sensoy, 2015 and Charlot, 2016) coupled with Markov switching regimes.

This issue is of great interest for portfolio managers and policy makers as well. For the former, understanding commodities' correlation structure is essential to accurately readjust their portfolios when the latter can improve their policies through a better understanding of the correlation structure. The purpose of our study is to assess the co-movements (measured by conditional correlations) of commodity indexes. Unlike other studies, we use energy, agricultural, precious metals and industrial metals from Rogers Commodity Index (RICI). Our aim is to examine, by using Markov Switching Regimes methodologies and the ADCC model, whether commodity's returns 'co-movements have registered a noticeable change and if that change is stable over time.

The literature on commodities' returns co-movements is extensive and remains inconclusive. Some authors consider the co-movements to be nonexistent (see Deb et al., 1996) or to be the result of misspecifications (see Deb et al., 1996)). Indeed, in this last study, the authors have criticized the model employed in the seminal work of Pindyck and Rotemberg (1990). They have shown that the findings are sensitive to conditional heteroskedasticity and to a neglected structural shift in the prices of certain commodities occurring in the mid-1970s. For others, the co-movements observed are related to the special context of the crises in 2000 and 2007-2008. Indeed, Buyuksahin et al. (2010) have proposed the concept of the "market of one" when co-movements increase between unrelated assets during turbulent times. Brunnermeier and Pedersen (2009) have explained this phenomenon by the behavior of actors selling all risky assets in an effort to raise liquidity and evade the "spiral loss" (See also Cheng et al., 2014).

More recent studies are in favor of increased co-movements due to changes in commodities' price levels and structure of dependence. Since the seminal work of Pindyck and Rotemberg (1990), several studies have reported the existence of co-movements between unrelated commodities before and after the 2007-2009 crisis (see, for example, Tang and Xiang, 2012, Adams and Glück, 2015, Basak and Pavlova, 2016 among others). Tang and Xiang (2012) conclude that the financialisation of commodities impacted their correlations starting from 2004 and have pointed out that the impact is stronger on index commodities compared to their non-index counterparts. This result is consistent with the massive inflow of investments from institutional investors as reported in Basak and Pavlova (2016). Indeed, the inflow of institutional investors resulted in a tightened relationship among unrelated commodities as well as with stock prices. As a consequence, the co-movements between these commodities have increased especially for index commodities. In an attempt to extract the explanatory variables, Le Pen and Sevi



(2018) have found that nine common factors might explain the excess co-movements between unrelated commodities. More importantly, they show that speculative trading emerges as a prominent factor. Their research emphasizes further the existence of co-movements in commodities independently from the special context of the crisis.

The premier objective of this article, in line with the existing literature, is to assess the co-movements and the so called financialization phenomenon, using conditional correlations, between the main index commodities categories. Our dataset spans the period from January 2000 to April 2018 allowing us to highlight all the changes that might have occurred in the correlation structure of commodities before and after the crisis. To extract the conditional correlations, we use the Asymmetric Conditional Correlations (ADCC) model developed by Cappiello et al. (2006) for it allows to capture the asymmetries in time-varying conditional correlations. Following the extraction step, we apply a Markov Switching Regimes setting on the correlation series' means. Departing from the relevant literature, this approach enables us to witness the changes and the changes' speed in the correlation structure as well as to pinpoint the dates at which these changes have occurred.

Our results show some of the main features attributed to the financialization. First, our results confirm the overall increase in correlation levels even among economically unrelated commodities. This is the case for the pairs: industrial metals-agriculture and precious metals-agriculture. Second, we detect at least one persistent regime for all the pairs of commodities except for the pair precious metals and agriculture commodities. Third, our results indicate that some pairs exhibit fast switches in the regimes detected. This is the case for the pairs: industrial metals-energy and agriculture-energy.

The remainder of the paper is organized as follows. The data and methodology are described in Section 2. Section 3 presents and discusses our empirical findings. Finally, Section 4 offers some concluding remarks and the policy implications of our findings.

## 2. Data and methodology

In this section, we first describe the data used before briefly presenting the ADCC model and the Markov switching regimes framework.

### 2.1.Data description

Our data consist of two brands of indexes: Rogers International Commodity Index (RICI). We focus on 4 subsets of the index (Agriculture, Energy, Precious Metals, and Industrial Metals). The Rogers series are daily and stretch from July 1998 to April 2018. The series were extracted from Bloomberg and served to compute the returns series.

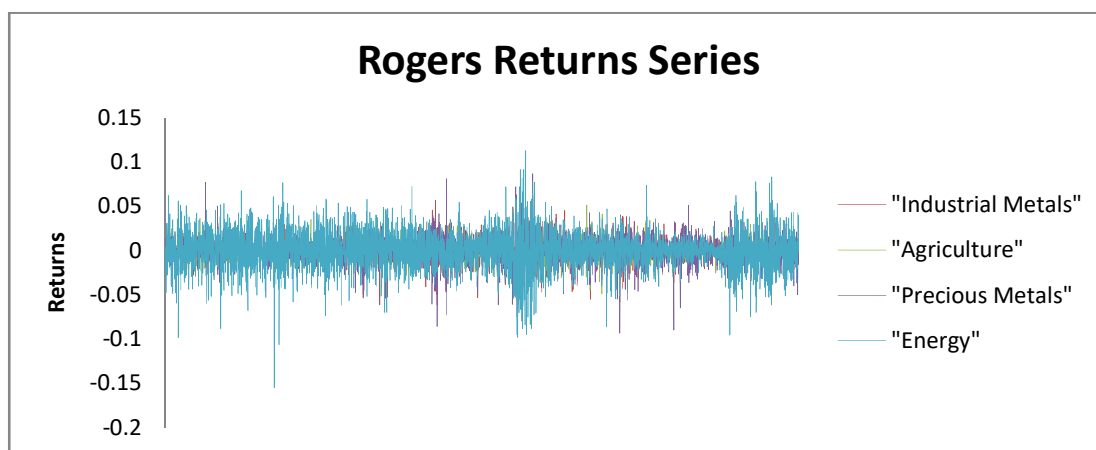


Fig1. shows the evolution of daily returns from the Rogers indices during the time span considered. In Fig.1, all series follow similar patterns.

All groups seem to peak around the years 2008/2009. The similarity in patterns and peaks are first signs of the existence of co-movements in these series.

Table 1. Descriptive statistics of the Rogers returns series

	IndustrialMetals (Rogers)	Agriculture (Rogers)	PreciousMetals (Rogers)	Energy (Rogers)
Mean	0.000206	-4.98E-05	0.000206	0.000153
Median	0	0	0	0
Maximum	0.061711	0.054476	0.087134	0.113148
Minimum	-0.065214	-0.058858	-0.093476	-0.154744
Std. Dev.	0.009542	0.007731	0.010507	0.016904
Skewness	-0.383628	-0.174987	-0.53513	-0.307722
Kurtosis	9.0661	9.564646	12.07461	8.30782
Jarque-Bera	11229.9***	12981.33***	25079.53***	8576.225***
Observations	7209	7209	7209	7209

As shown in Table 1, the series exhibit means close to zero and medians of 0. Furthermore, the series show low levels of volatility below or around 1% for most cases. On another note, the Jarque-Bera tests of normality along with the values of Kurtosis and Skewness, picture series skewed to the left, leptokurtic as their respective kurtosis are above the value of 3 and non normal distributions as the Jarque-Bera tests indicate.

## 2.2. The methodology

### 2.2.1 The GARCH model

The seminal work of Engle on the autoregressive conditional heteroscedasticity (ARCH) model is matched only by Bollerslev's generalized ARCH (GARCH) model. Formally ARCH and GARCH model have affixed to them order numbers, e.g. GARCH (p,q) where p, q are the order numbers. In practice, a GARCH (1,1) model often suffice. In this thesis, if no order numbers are stated it will be implied that these are of the lowest non-trivial order. The GARCH model is defined as follows:

$$\begin{aligned}
 y_t | \mathcal{F}_{t-1} &\sim D(0, h_t) \\
 h_t &= \alpha_0 + \alpha_1 y_{t-1}^2 + \beta h_{t-1} \\
 \alpha_0 > 0, \alpha_1 \geq 0, \beta &\geq 0
 \end{aligned} \tag{1}$$

where  $y_t$  comes from a time-series process,  $\mathcal{F}_{t-1}$  the information set up to  $t - 1$ ,  $D$  is a probability distribution,  $h_t$  is the variance at time  $t$  and  $\alpha_0$ ,  $\alpha_1$  and  $\beta$  are the parameters implying the dynamics of the variance.

A sufficient condition for variance stationarity is  $\alpha_1 + \beta < 1$ . Assuming the distribution to be Gaussian, the log-likelihood function becomes:

$$l_{vol}(\theta) = -\frac{1}{2T} \sum_{t=1}^T \left( \log(h_t) + \frac{y_t^2}{h_t} \right) \quad (2)$$

where the parameters of interest are collected in the vector  $\theta$ . Even if the Gaussian assumption is not fulfilled but

$$\begin{aligned} E(y_t | \mathcal{F}_{t-1}) &= 0, \\ E(y_t^2 | \mathcal{F}_{t-1}) &= h_t, \\ E(y_t^4 | \mathcal{F}_{t-1}) &< \infty \end{aligned} \quad (3)$$

is true, then equation 4 will still hold a quasi-maximum likelihood estimation (MLE) interpretation, i.e. the estimate will be consistent. Assuming instead a student  $t$  distribution the log-likelihood becomes

$$l_{vol}(\theta) = -\frac{1}{2} \sum_{t=1}^T \log h_t - \frac{\nu + 1}{2} \sum_{t=1}^T \log \left( 1 + \frac{y_t^2}{h_t(\nu - 2)} \right) \quad (4)$$

$\nu > 2.$

Looking at the equation for the variances (1), a few observations beg to be made. First of all, the equation has three parameters to estimate and they lend themselves to a fairly natural interpretation.  $\alpha_0$  is an intercept term,  $\alpha_1$  dictates the impact of the squared residuals on the future variance and finally  $\beta$  does the same thing for the previous variance term. Secondly, notice that the residuals enter the equation in squared form, thus doing away with information on the sign (positive or negative) of the innovation. This is undesirable in many financial contexts. It has, for instance, been found that volatility increases more following negative returns than they do following positive returns.

## 2.2.2 ADCC model

Assume a  $k \times 1$  vector  $y_t$  and let it (for the sake of simplicity) be conditionally multivariate normal:

$$y_t | \mathcal{F}_{t-1} \sim N(0, H_t) \quad (5)$$

where  $H_t$  is a  $k \times k$  covariance matrix. The key step lies in decomposing the covariance matrix into a diagonal matrix of the standard deviations,  $D_t$ , and a correlation matrix,  $R_t$ :

$$H_t = D_t R_t D_t \quad (6)$$

This leads to a two-step estimation of the covariance matrix. The first step, estimating the standard deviations, has implicitly been dealt with. The second step, estimating the correlation matrix, is the subject of the rest of the section. Using the multivariate normal distribution,

$$\left(\frac{1}{2\pi}\right)^{n/2} \frac{1}{\sqrt{|\Sigma|}} \exp\left(-\frac{1}{2}(x - \mu)' \Sigma^{-1}(x - \mu)\right) \quad (7)$$

where  $\Sigma$  is the covariance matrix and  $\mu$  the mean vector. The loglikelihood function for the correlation part can be written as:

$$l_{corr}(\theta) = -\frac{1}{2} \sum_t (\log(|R_t|) + \tilde{y}_t R_t^{-1} \tilde{y}_t'). \quad (8)$$

An  $R_t$  positive definite matrix implies that  $H_t$  is also positive definite. This can be achieved by decomposing the correlation matrix as follows:

$$R_t = (I \odot Q_t)^{-1/2} Q_t (I \odot Q_t)^{-1/2} \quad (9)$$

where  $Q_t$ , the correlation evolution process, in the scalar ADCC case, is given by:

$$Q_t = (\bar{Q} - \alpha \bar{Q} - \beta \bar{Q} - \gamma \bar{N}) + \alpha \tilde{y}_{t-1} \tilde{y}_{t-1}' + \gamma n_{t-1} n_{t-1}' + \beta Q_{t-1} \quad (10)$$

where  $n_t = I[\tilde{y}_t < 0] \odot \tilde{y}_t$ ,  $\bar{N} = E[n_t n_t']$  (or the empirical counterpart:  $\frac{1}{T} \sum_{t=1}^T n_t n_t'$  to simplify matters)

and  $\bar{Q} = E[\tilde{y}_{t-1} \tilde{y}_{t-1}']$  (or the empirical counterpart:  $\frac{1}{T} \sum_{t=1}^T \tilde{y}_{t-1} \tilde{y}_{t-1}'$ ). The following condition is a necessary and sufficient condition for  $Q_t$  to be positive definite:

$$\alpha + \beta + \delta\gamma < 1$$

where  $\delta$  is the maximum eigen value of  $\bar{Q}^{-1/2} \bar{N} \bar{Q}^{-1/2}$ . A positive definite  $Q_t$  results in a positive definite  $R_t$  as the latter is a rescaling of the former. Notice that the dynamics of  $Q_t$  is very similar to that of the (univariate) GJR model. Also setting  $\gamma = 0$  reduces to the DCC model and setting  $\alpha = 0, \beta = 0$  reduces it further to the CCC model.

### 2.2.3 Markov Switching Regimes

A Markov switching model is constructed by combining two or more dynamic models via a Markovian switching mechanism. Following Hamilton (1989, 1994), we shall, more specifically, focus on the Markov switching autoregressive (AR) model. We will illustrate a simple model to show the features of this model.

$$z_t = \begin{cases} \alpha_0 + \beta z_{t-1} + \varepsilon_t, & s_t = 0, \\ \alpha_0 + \alpha_1 + \beta z_{t-1} + \varepsilon_t, & s_t = 1, \end{cases} \quad (11)$$

where  $|\beta| < 1$  and  $\varepsilon_t$  are i.i.d. random variables with mean zero and variance  $\sigma_\varepsilon^2$ . This is a stationary AR(1) process with mean  $\alpha_0/(1 - \beta)$  when  $s_t = 0$ , and it switches to another stationary AR(1) process with mean  $(\alpha_0 + \alpha_1)/(1 - \beta)$  when  $s_t$  changes from 0 to 1. Then, provided that  $\alpha_1 \neq 0$ , this model admits two dynamic structures at different levels, depending on the value of the state variable  $s_t$ . In this case,  $z_t$  are governed by two distributions with distinct means, and  $s_t$  determines the switching between these two distributions (regimes). When  $s_t = 0$  for  $t = 1, \dots, \tau_0$  and  $s_t = 1$  for  $t = \tau_0 + 1, \dots, T$ , the model (1) is the model with a single structural change in which the model parameter experiences one (and only one) abrupt change after  $t = \tau_0$ . When  $s_t$  are independent Bernoulli random variables, it is the random switching model of Quandt (1972). In the random switching model, the realization of  $s_t$  is independent of the previous and future states so that  $z_t$  may be “jumpy” (switching back and forth between different states). If  $s_t$  is postulated as the indicator variable  $I\{\lambda_t \leq c\}$  such that  $s_t = 0$  or 1 depending on whether the value of  $\lambda_t$  is greater than the cut-off (threshold) value  $c$ , (1) becomes a threshold model. It is quite common to choose a lagged dependent variable (say,  $z_{t-d}$ ) as the variable  $\lambda_t$ .

While these models are all capable of characterizing the time series behaviors in two regimes, each of them has its own limitations. For the model with a single structural change, it is very restrictive because only one change is admitted. Although extending this model to allow for multiple changes is straightforward, the resulting model estimation and hypothesis testing are typically cumbersome; see e.g., Bai and Perron (1998) and Bai (1999). Moreover, changes in such models are solely determined by time which is exogenous to the model. The random switching model, by contrast, permits multiple changes, yet its state variables are still exogenous to the dynamic structures in the model. This model also suffers from the drawback that the state variables are independent over time and hence may not be applicable to time series data. On the other hand, switching in the threshold model is dependent and endogenous and results in multiple changes. Choosing a suitable variable  $\lambda_t$  and the threshold value  $c$  for this model is usually a difficult task, however.

One approach to circumventing the aforementioned problems is to consider a different specification for  $s_t$ . In particular, suppose that  $s_t$  follows a first order Markov chain with the following transition matrix:

$$\mathbf{P} = \begin{bmatrix} \mathbb{P}(s_t = 0 | s_{t-1} = 0) & \mathbb{P}(s_t = 1 | s_{t-1} = 0) \\ \mathbb{P}(s_t = 0 | s_{t-1} = 1) & \mathbb{P}(s_t = 1 | s_{t-1} = 1) \end{bmatrix} \quad (12)$$

$$= \begin{bmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{bmatrix},$$

where  $p_{ij}$  ( $i, j = 0, 1$ ) denote the transition probabilities of  $s_t = j$  given that  $s_{t-1} = i$ . Clearly, the transition probabilities satisfy  $p_{i0} + p_{i1} = 1$ . The transition matrix governs the random behavior of the state variable, and it contains only two parameters ( $p_{00}$  and  $p_{11}$ ). The model (1) with the Markovian state variable is known as a Markov switching model. The Markovian switching mechanism was first considered by Goldfeld and Quandt (1973). Hamilton (1989) presents a thorough analysis of the Markov switching model and its estimation method (see also Hamilton, 1994 and Kim and Nelson, 1999).

In the Markov switching model, the properties of  $z_t$  are jointly determined by the random characteristics of the driving innovations  $\varepsilon_t$  and the state variable  $s_t$ . In particular, the Markovian state variable yields random and frequent changes of model structures, and its transition probabilities determine the persistence of each regime. While the threshold model also possesses similar features, the Markov switching model is relatively easy to

implement because it does not require choosing a priori the threshold variable  $\lambda_t$ . Instead, the regime classification in this model is probabilistic and determined by data. A difficulty with the Markov switching model is that it may not be easy to interpret because the state variables are unobservable.

### 3. Empirical results and discussion

In this section, we present and discuss our main results by analyzing pair wise of commodity groups.

#### 3.1 Correlations between Energy and Industrial Metals groups

The dynamics of this pair of commodities correlation can be mainly explained by economic arguments underlying their relationship. Following Table 2, the average correlation between energy and industrial metals commodities is around 0.3 indicating an intermediate level of correlation<sup>23</sup>. Furthermore, an inspection of Fig.2, allows us to distinguish three periods. The first period starts roughly in 2000 and ends up at the beginning of 2008. As this figure indicates, this phase is characterized by a general growing level of correlations punctuated by drops<sup>24</sup> corresponding mainly to a very sharp increase in oil prices<sup>25</sup>. During this first sub-period, correlations are stable but at high level (the highest correlation is equal to 0.72 is reached within this period) before a collapse around 2010 and a long decline until 2015. Finally, the last period can be qualified as a “mean reversion” period as correlations were reverted to the levels observed in the 2000s. This evolution is very volatile as the standard deviation reaches 0.1 (see Table 2).

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<sup>23</sup> We define, in absolute values, a high level of correlation when the average is around or above 0.6, an intermediate level of correlation when the mean is between 0.2 and 0.5 and finally a low correlation level when the mean is between 0 and 0.2.

<sup>24</sup> The drops corresponds to sharp increases like in 2004 where the adjusted price for inflation of oil reached around 50\$ compared to 38\$ in the previous year. The prices presented are yearly prices.

<sup>25</sup> Crude oil and Brent represent 40% and 32.5% of the energy index in Rogers Commodity index respectively.



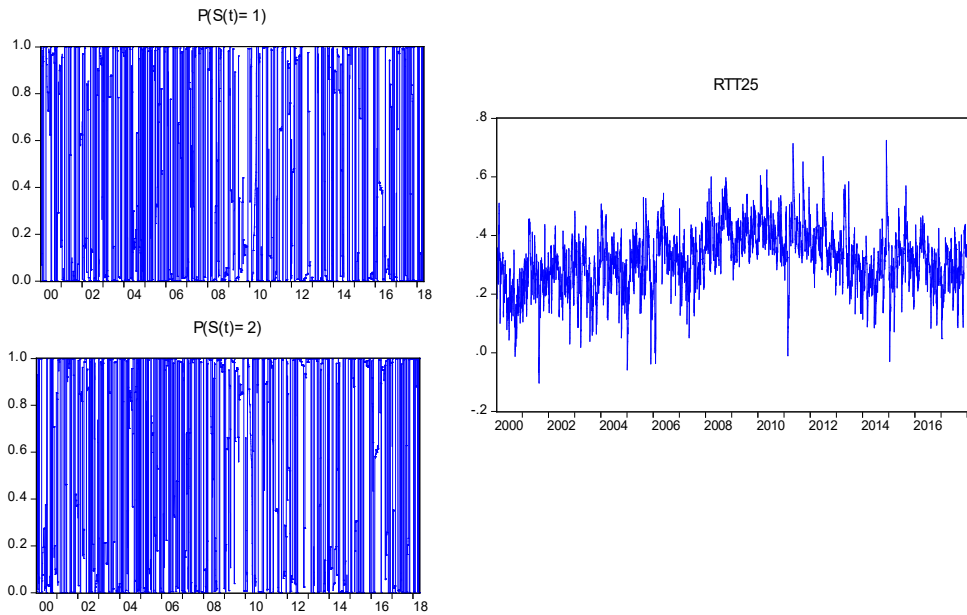


Fig.2 Smoothed probabilities (Left) and conditional correlation graph (Right) for the energy and industrial metals commodities groups

We detect the presence of two persistent regimes as the probability for staying in the same regime is higher than 0.9. Furthermore, the regimes appear to be fast shifting since the average duration for each regime is less than 60 days<sup>26</sup>. The detected regimes are consistent with the volatile nature of the correlation series as they switch from an average level of 0.2 to an average of 0.4 throughout the period studied.

Table 2. Summary statistics of Markov switching regimes for the Industrial Metals-Energy pair

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: RTT23S				
Method: Markov Switching Regression (BFGS / Marquardt steps)				
Date: 11/03/19 Time: 18:01				
Sample: 1/14/2000 4/26/2018				
Included observations: 6678				
Number of states: 2				
Initial probabilities obtained from ergodic solution				
Standard errors & covariance computed using observed Hessian				
Random search: 25 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=1842911942)				
Failure to improve objective (non-zero gradients) after 2 iterations				
Regime 1				
C	0.400242	0.001790	223.5441	0.0000
Regime 2				
C	0.312935	0.000710	440.5052	0.0000
Common				
AR(1)	0.750111	0.014915	50.29322	0.0000
AR(2)	0.114296	0.014944	7.648229	0.0000
LOG(SIGMA)	-5.149475	0.009358	-550.2839	0.0000
Transition Matrix Parameters				
P11-C	-0.103461	0.441171	-0.234516	0.8146
P21-C	-12.21608	5.503124	-2.219844	0.0264
Mean dependent var	0.316985	S.D. dependent var	0.012415	
S.E. of regression	0.009043	Sum squared resid	0.545745	
Durbin-Watson stat	0.901930	Log likelihood	25126.56	
Akaike info criterion	-7.523080	Schwarz criterion	-7.515945	
Hannan-Quinn criter.	-7.520616			
Inverted AR Roots	.88	- .13		

<sup>26</sup> 51 days and 63 days for the regimes 1 and 2 respectively.

These observations are consistent with the stylized facts reported in the relevant literature on this topic. The first feature is associated with the highly volatile nature of the correlation series and the resulting fast shifts between regimes. The manufacturing of metals is a heavy energy process from the extraction of minerals to the processing and transportation of the end products like iron, zinc, and copper among others (see Hammoudeh et al. (2014)). As a consequence, metals' prices are very sensitive to the fluctuations of energy commodities' prices, especially, oil prices. The second feature is related to the observed evolution in the correlation series. Energy prices, especially oil prices, are informative leading indicators of economic cycles. Killian (2009) has documented that oil prices can be a signal for a global boom or a bust cycle<sup>27</sup>. In a boom cycle, the author has argued that increasing oil prices are accompanied by large revenues covering higher costs of energy. Therefore, the demand and the production of metals increase following the same pattern as energy prices. This situation is the same observed in the first period identified earlier. However, when the prices of oil are too high, economies tend to suffer resulting in lower demand and prices for metals. This induces a weakened correlation as observed in the second period. The last period corresponds to a recovery where the correlations revert to their original levels.

An alternative explanation is given by Sockin and Xiong (2012). The authors have suggested that the inflow of investors into the commodity trade (referred to as “financialization” of commodities) has brought too much noise to the information discovery process in commodities. As a result, goods producers cannot rule out the causes behind commodities' prices movements as being changes in global economic fundamentals or as being a result of herding behaviors. A consequence would be a heightened connection between energy prices and metals' prices as higher oil prices can be interpreted as a signal for a higher global demand to come.

### **3.2 Correlations between Energy and Agriculture groups**

High fluctuations in energy prices over recent years in relation with policies promoting renewable energy have substantially modified the relationship between energy and agriculture commodities. Traditionally, agriculture intensively used directly or indirectly energy. However, as a consequence of the sharp increase in energy prices and the adoption of biofuels policies, agricultural commodities are used to produce biofuels. It follows that agricultural products may be considered as substitutes for fossil fuels implying important repercussions on the correlation between energy and agricultural commodities. As reported in Table 3, the average correlation is around 0.28

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<sup>27</sup> A global boom cycle refers to the economic state where all economies have a synchronized boom cycle.

indicating an intermediate level of correlation. However, the correlation series are very volatile as the standard deviation reaches 0.2 (the highest among all the correlation series presented) with values ranging from a maximum of 0.92 to a minimum of -0.74. Fig.3 reveals that two periods can be distinguished. The first, from 2000 to 2008, where the maximum value of the standard deviation is reached, is characterized by a growing correlation level. The second period (2009 to 2018) corresponds to a slight decrease in correlations compared to the previous one.

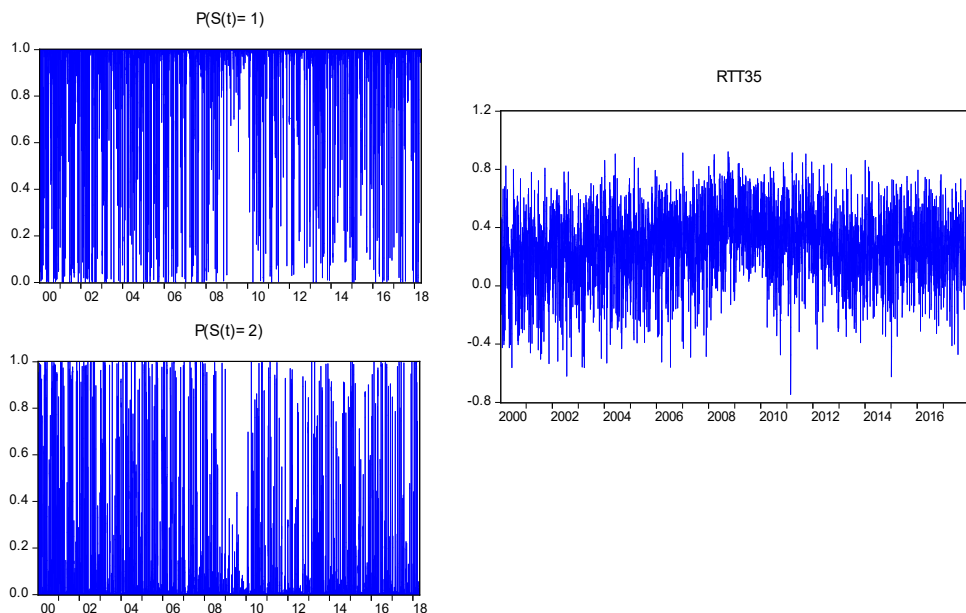


Fig.3 Smoothed probabilities (Left) and correlation graph (Right) for the energy and agriculture commodities groups

We detect the presence of one persistent regime as the probability for staying in the same regime is higher than 0.9 and the probability of staying in regime 2 is 0.5. We can observe a symmetric pattern around 2008 in the smoothed probabilities. Our result is in line with the relevant literature. Indeed, many papers report a strong comovement between energy – especially oil- and agriculture commodities (see Baffes (2007), Chang and Su (2010), Wu et al.(2011), Du et al. (2011), Nazlioglu et al. (2013), Mensi et al. (2014) and Kumar (2017)). Among the explanations given for the observed relationship between energy and agriculture commodities, the two following stand out. First, some researchers attribute this correlation levels to the increased use of biofuels as a substitute to traditional fossil fuels, oil, in particular. As reported in Chang and Su (2010), many agriculture commodities such as corn, soy and sugar are used extensively to produce biofuels. In the same line of thought, Hochman et al. (2014) have noticed that 25% of corn prices are driven by biofuels, while 7% of soybean prices are driven by energy prices. Furthermore, an increased production of some agricultural commodities (for example, corn or maize) translates into a reallocation of the soils for other agricultural commodities (for example, wheat). As a result, the

latter commodities see their prices skyrocket because of the land shortage even in the presence of high stocks (see Baffes and Hanniotis (2010), Wu et al. (2011) and deGorter et al. (2013) among others).

Table 3. Summary statistics of Markov switching regimes for the Energy-Agriculture pair

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: RTT25				
Method: Markov Switching Regression (BFGS / Marquardt steps)				
Date: 07/11/19 Time: 21.26				
Sample: 1/14/2000 4/26/2018				
Included observations: 6678				
Number of states: 2				
Initial probabilities obtained from ergodic solution				
Standard errors & covariance computed using observed Hessian				
Random search: 25 starting values with 10 iterations using 1 standard deviation (mg=kn, seed=1157423601)				
Convergence achieved after 17 iterations				
Regime 1				
C	0.246848	0.008221	30.02505	0.0000
Regime 2				
C	0.363342	0.008245	44.06850	0.0000
Common				
AR(1)	0.955560	0.014450	66.13019	0.0000
AR(2)	0.005605	0.014511	0.386235	0.6993
LOG(SIGMA)	-3.641746	0.009520	-382.5543	0.0000
Transition Matrix Parameters				
P11-C	2.827765	0.100455	28.14968	0.0000
P21-C	-3.129895	0.092549	-33.81869	0.0000
Mean dependent var	0.319618	S.D. dependent var	0.101234	
S.E. of regression	0.036246	Sum squared resid	8.766644	
Durbin-Watson stat	2.042610	Log likelihood	13661.74	
Akaike info criterion	-4.089469	Schwarz criterion	-4.082334	
Hannan-Quinn criter.	-4.087004			
Inverted AR Roots	.96	-.01		

Second, these co-movements could be explained by the extensive use of commodities in portfolios (see Baffes and Hanitis, 2010, Singleton, 2014, Tang and Xiong, 2012). They have argued that, following the collapse of the equity market in 2000, institutional investors invested into agricultural commodities either through futures or indexes. Creti et al. (2013), more specifically, study the Goldman and Sacks Commodity index (GSCI) and distinguish the baseline movements from the extreme ones. When GSCI is high, fund managers, by investing through a commodity index, influence commodity markets. As this index does not merely reflect the macroeconomic conditions of agricultural products – as it includes several commodities – this might induce a deviation of prices from their fundamental values. Indeed, investors may take positions in agricultural markets with respect to the value of the commodity index. This result strengthens the financialization of agricultural commodities through this channel.

### 3.3 Correlations between Energy group and Precious Metals group

As shown in Table 4, the average correlation is around 0.28 indicating an intermediate level of correlation. As depicted in Fig.4, this correlation series is stable around the mean with some sharp fluctuations (with a maximum of around 0.4). Some peaks are observed for the lowest values (the lowest value is 0.2) in 2001 and in 2004 and for the highest values in 2013 and in 2014 (the highest value is 0.4). Furthermore, the standard deviation is low (equal to 0.01) indicating a very low level of volatility.

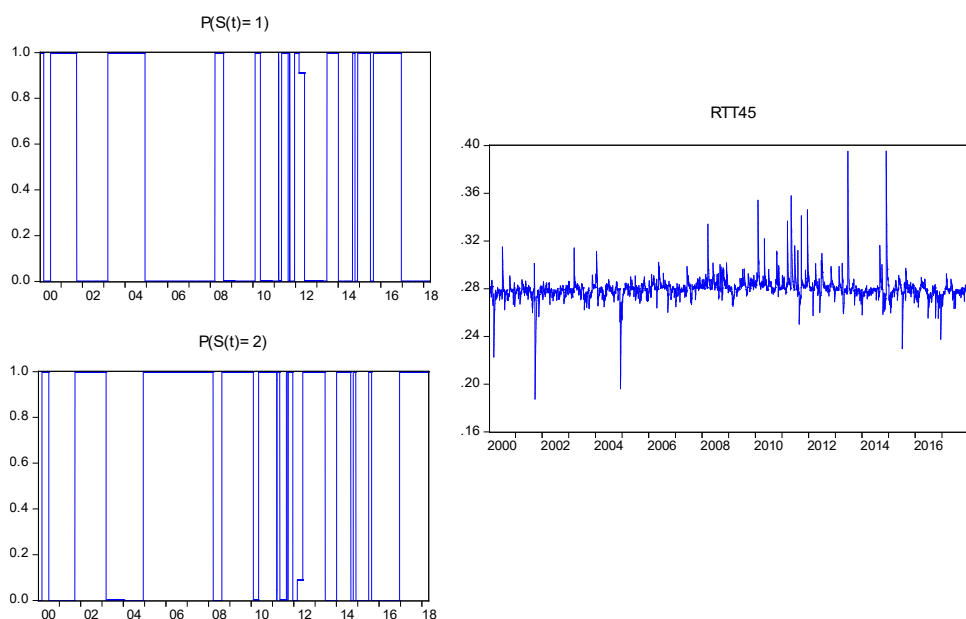


Fig.4 Smoothed probabilities (Left) and correlation graph (Right) for the energy and precious metals commodities groups

We detect the presence of two persistent regimes as the probability for staying in the same regime is higher than 0.9. Furthermore, the two regimes seem to correspond to short-term cycles since the average duration for each regime is higher than 200 days<sup>28</sup>.

<sup>28</sup> 209 days and 324 days for the regimes 1 and 2 respectively.

Table 4. Summary statistics of Markov switching regimes for the Precious Metals-Energy pair

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: RTT24				
Method: Markov Switching Regression (BFGS / Marquardt steps)				
Date: 11/03/19 Time: 18:19				
Sample: 1/14/2000 4/26/2018				
Included observations: 6678				
Number of states: 2				
Initial probabilities obtained from ergodic solution				
Standard errors & covariance computed using observed Hessian				
Random search: 200 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=228968279)				
Failure to improve objective (non-zero gradients) after 8 iterations				
Regime 1				
C	0.696418	0.001091	638.4230	0.0000
Regime 2				
C	0.717848	0.001576	455.3980	0.0000
Common				
AR(1)	0.758629	0.017430	43.52397	0.0000
AR(2)	0.161251	0.017603	9.160208	0.0000
LOG(SIGMA)	-5.232750	0.012992	-402.7695	0.0000
Transition Matrix Parameters				
P11-C	4.850923	0.145571	33.32342	0.0000
P21-C	-0.607337	0.431992	-1.405897	0.1598
Mean dependent var	0.700230	S.D. dependent var	0.010581	
S.E. of regression	0.004676	Sum squared resid	0.145935	
Durbin-Watson stat	1.643956	Log likelihood	26763.37	
Akaike info criterion	-8.013288	Schwarz criterion	-8.006154	
Hannan-Quinn criter.	-8.010824			
Inverted AR Roots	.93	-.17		

This result is in line with the findings of Sari et al. (2010). The authors find that energy prices, mostly oil prices, have a very weak relationship with gold<sup>29</sup>, while having a stronger relationship with silver<sup>30</sup>. In the case of gold, the authors give several explanations to this weak relationship. First, gold prices are the least volatile within the precious metals' group, while oil prices are very volatile. As a matter of fact, gold is commonly known as a reserve currency and a "safe haven" exhibiting a low level of volatility. Second, changes in oil prices may affect gold prices but the reverse is rarely true with a very small effect. Indeed, changes in oil prices can affect many financial variables, which in turn affect gold prices since gold is perceived as a safe haven. However, when gold prices move due to economic fundamentals like the demand in the jewelry industry or as result of a hoarding for gold, oil prices do not react. Hence, the absence of a bidirectional link weakens greatly the correlation between the two commodities. In the case of silver, the two commodities have many common features. First, their prices are both volatile strengthening their potential correlation. Second, the two commodities are important inputs for the automobile industry. Therefore, and in accordance with Basak and Pavlova (2016), this industry, for example, can act as a common factor for the two commodities leading to a higher correlation.

<sup>29</sup> Gold is the heaviest component of the Rogers Precious metals sub index with a percentage of 45%

<sup>30</sup> Silver is the second heaviest component of the Rogers Precious metals sub index with a percentage of 36%

### 3.4 Correlations between Industrial Metals group and Precious Metals group

As is specified in Table 5, the average correlation is around 0.7 indicating a high level of correlation. This correlation series is stable around the mean (see Fig.5) with some sharp fluctuations (with a maximum of 0.82). Some notable peaks are reached in 2004 (the lowest value observed is of 0.48) and in 2007. Moreover, the standard deviation is very low and equal to 0.01.

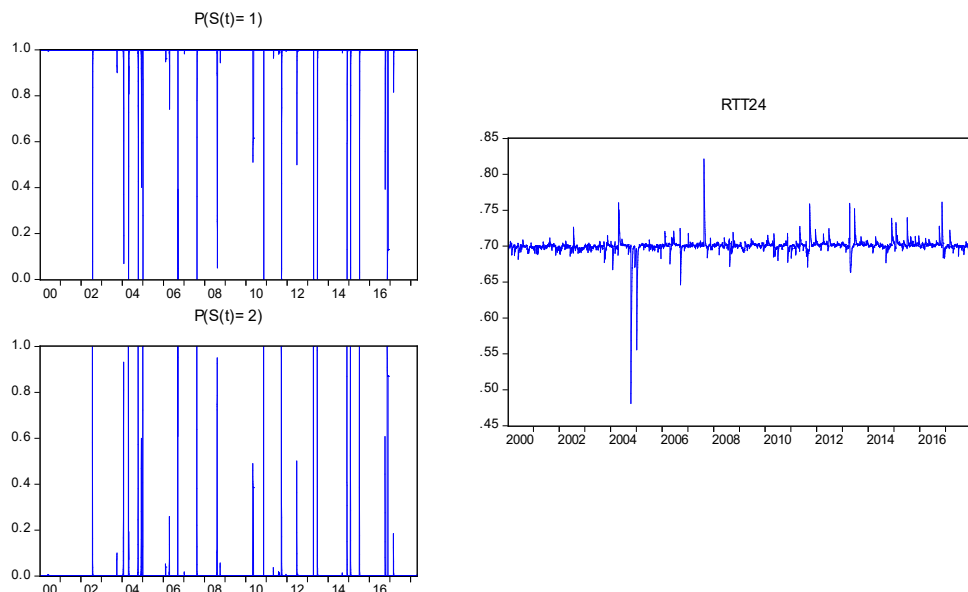


Fig.5 Smoothed probabilities (Left) and correlation graph (Right) for the industrial and precious metals commodities groups

We detect the presence of one persistent regime as the probability for staying in the same regime is higher than 0.9 and the probability of staying in regime 2 is 0.62. Our result is consistent with some results stated in the literature. Fernandez (2015b) has reported similar high levels of correlations. For instance, she has found levels of concordance<sup>31</sup> to gold and to silver superior to 0.6. The same result is put forward in Sensoy et al. (2015). Among the critical factors that drove up co-movements among metal commodity futures, two of them emerge as the most prominent: the increased use of these commodities for portfolio diversification and hedging purposes following the intensifying financialization of commodity markets, and possible speculative strategies from mid-2000s, particularly during the global financial crisis of 2008–2009. However, they concede that these co-movements deserve a thorough research.

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<sup>31</sup>This statistic allows one to measure the proportion of time that the average influences of two commodities are simultaneously in the same boom or slump period in a scale of 0 to 1.

Table 5. Summary statistics of Markov switching regimes for the Industrial Metals-Precious Metals pair

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: RTT35				
Method: Markov Switching Regression (BFGS / Marquardt steps)				
Date: 11/04/19 Time: 16:11				
Sample: 1/14/2000 4/26/2018				
Included observations: 6678				
Number of states: 2				
Initial probabilities obtained from ergodic solution				
Standard errors & covariance computed using observed Hessian				
Random search: 100 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=449923223)				
Convergence achieved after 12 iterations				
Regime 1				
C	0.310635	0.005416	57.35412	0.0000
Regime 2				
C	-0.104481	0.012603	-8.290231	0.0000
Common				
AR(1)	0.596529	0.015554	38.35203	0.0000
AR(2)	0.003353	0.014896	0.225080	0.8219
LOG(SIGMA)	-1.935835	0.012288	-157.5430	0.0000
Transition Matrix Parameters				
P11-C	2.996790	0.094572	31.68783	0.0000
P21-C	-0.169241	0.136461	-1.240218	0.2149
Mean dependent var	0.271487	S.D. dependent var	0.213150	
S.E. of regression	0.179033	Sum squared resid	213.8877	
Durbin-Watson stat	2.032361	Log likelihood	2309.706	
Akaike info criterion	-0.689639	Schwarz criterion	-0.682505	
Hannan-Quinn criter.	-0.687175			
Inverted AR Roots	60	-.01		

### 3.5 Correlations between Industrial Metals group and Agriculture group

Table 6 shows that the average correlation is around 0.32, which corresponds to an intermediate level of correlation. This correlation series is stable around the mean with punctual sharp fluctuations (with a maximum of around 0.57). Some notable peaks are reached around 2004, 2008 and 2012 (see Fig.6). Furthermore, the standard deviation is low around 0.01 indicating a very low level of volatility.



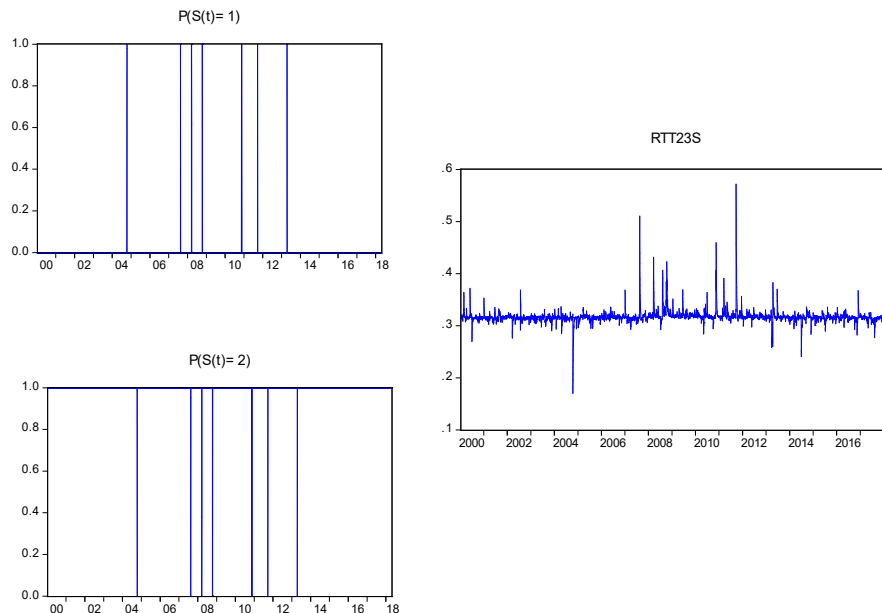


Fig.6 Smoothed probabilities (Left) and correlation graph (Right) for the industrial and agriculture commodities groups

We detect the presence of one persistent regime as the probability for staying in the same regime is higher than 0.9 and the probability of staying in regime 2 is 0.52. It is worth pointing out that there is not, a priori, an economic fundamental link between the two groups. Therefore, the existence of an intermediate level of correlation is puzzling. However, a possible explanation could be given through the concept defined by Basak and Pavlova (2016). As discussed above, the inflow of investments made in index commodities could have increased the correlation levels of both the pairs industrial metals - energy and agriculture-energy. Therefore, energy has become a “common factor” between these two “unrelated” groups as stated by the authors in Basak and Pavlova (2016). Another possible explanation would be the substitution effect between the agriculture and the energy groups. As discussed in sub section 3.3, agriculture commodities tend to serve as inputs for the production of biofuels. As a result, the metal industry could be using this alternative fuel in order to cut some of the costs of increasing oil prices. An example of this substitution would be the machinery industry. This industry is energy intensive as 2/3 of its costs come from energy. As a consequence, the industry developed the use of biofuels as a mean to hedge against sharp fluctuations in oil prices. Nevertheless, this issue needs further research.

Table 6. Summary statistics of Markov switching regimes for the Industrial Metals-Agriculture pair

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: RTT45				
Method: Markov Switching Regression (BFGS / Marquardt steps)				
Date: 07/11/19 Time: 21:28				
Sample: 1/14/2000 4/26/2018				
Included observations: 6678				
Number of states: 2				
Initial probabilities obtained from ergodic solution				
Standard errors & covariance computed using observed Hessian				
Random search: 25 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=1339107479)				
Convergence achieved after 19 iterations				
Regime 1				
C	0.282666	0.003435	82.29449	0.0000
Regime 2				
C	0.235377	0.003517	66.92323	0.0000
Common				
AR(1)	0.970828	0.012518	77.55490	0.0000
AR(2)	0.025302	0.012519	2.021076	0.0433
LOG(SIGMA)	-5.742991	0.008659	-663.2229	0.0000
Transition Matrix Parameters				
P11-C	5.337939	0.282549	18.89208	0.0000
P21-C	-5.777835	0.279662	-20.66007	0.0000
Mean dependent var	0.279835	S.D. dependent var	0.009623	
S.E. of regression	0.004334	Sum squared resid	0.125335	
Durbin-Watson stat	2.106483	Log likelihood	28712.01	
Akaike info criterion	-8.596889	Schwarz criterion	-8.589754	
Hannan-Quinn criter.	-8.594424			
Inverted AR Roots	1.00	-.03		

### 3.6 Correlations between Precious Metals group and Agriculture group

The correlation is constant around 0.27 indicating an intermediate level of correlation and this correlation series is flat with no volatility (Fig.7). Moreover, we fail to detect the presence of any regimes given the nature of correlation series obtained.

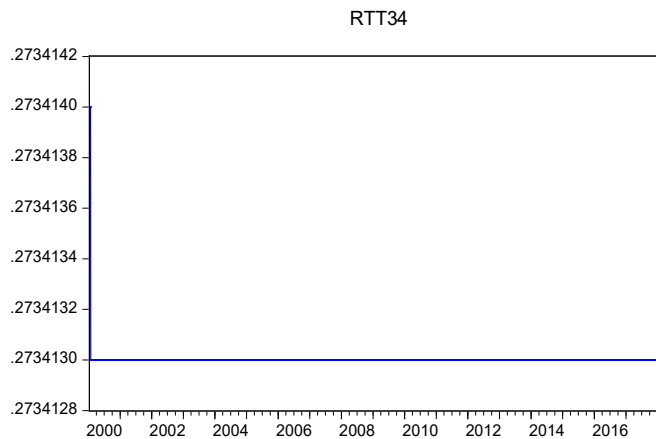


Fig.7 Correlation graph for the precious metals and agriculture commodities groups

This pair of commodities is another example as in the previous section of seemingly unrelated commodities. Using the same argument, we could refer to the strong correlation levels between precious metals and industrial metals to explain the presence of an intermediate level of correlation between the two current commodities. Indeed,

as industrial metals exhibit an intermediate level correlation with agriculture commodities and as precious metals exhibit a high level correlation with industrial metals, industrial metals can be viewed as a common factor justifying this intermediate level of correlation between those two commodities.

#### **4. Conclusion**

The purpose of this article is to assess the co-movements and the so called “financialization” phenomenon using conditional correlations, between the main index commodities categories following a Markov Switching Regimes methodology and the ADCC model.

Our results highlight some of the main features attributed to financialization. First, they confirm the overall increase in correlation levels even among economically unrelated commodities. This is effectively the case for the pairs: industrial metals-agriculture and precious metals-agriculture. Second, our results indicate that some pairs exhibit fast switches in the regimes detected. This is the case for the pairs: industrial metals-energy and agriculture-energy.

We claim that the financialization has strengthened the integration between index commodities as we find at least an intermediate level of correlations in all cases. Furthermore, our results underline the fact that financialization strongly influences the information discovery channel of commodities. As a matter of fact, the fast switches in regimes can indicate that the producers can no longer rely on the prices to predict the state of demand and supply. Finally, index commodities seem no longer to serve as effective hedging vehicles as before 2000s in regard to the correlation levels observed.

Further research should be done on this topic in order to determine the magnitude of the financialization on individual commodities and the channels through which this phenomenon affects the dependence structure of this asset class.

# Conclusion générale

Dans cette thèse doctorale, nous avons analysé la financiarisation des matières premières et marchandises sous deux angles : l'angle informationnel (les chapitres 1 et 2) et l'angle des corrélations (le chapitre 3). Nous avons examiné l'impact d'annonces spécifiques aux marchés des matières premières sur ces derniers (chapitre 1), avant d'analyser l'impact de ces mêmes annonces sur les secteurs économiques (chapitre 2). Enfin, nous avons étudié la structure de corrélations entre les principaux marchés de matières premières et marchandises (chapitre 3).

Dans le premier chapitre, nous évaluons l'impact des annonces de l'OPEP sur la formation du prix de pétrole de 1991 à 2015. Notre méthodologie consiste en une étude d'événement utilisant un modèle de marché pour mesurer les écarts anormaux et un modèle EGARCH pour prendre en compte le caractère volatil des prix de pétrole. Notre approche a l'avantage d'être adaptée à l'étude des effets d'annonce et de capturer toutes les annonces de l'OPEP contrairement à la littérature sur le sujet. A l'issue de cette étude, nous constatons que l'impact informationnel de l'OPEP dépend du niveau des prix de pétrole. Plus précisément, cet effet est plus prononcé quand le niveau des prix est faible. Cette situation a l'avantage de réduire la concurrence de produits substitués au pétrole comme le pétrole non conventionnel ou encore les biocarburants.

Le deuxième chapitre s'inscrit dans la continuité du premier dans la mesure où nous nous intéressons aux annonces de l'OPEP et utilisons la même méthodologie (études d'événements et modèle EGARCH), mais il s'en distingue puisqu'il porte sur l'effet de ces annonces sur le rendement des actions européennes de tous les secteurs économiques. Aussi, contrairement au chapitre 1, à la place du modèle de marché, nous associons à l'étude d'événements un modèle Fama-French à 3 facteurs pour la mesure des écarts anormaux. Notre étude complète très utilement la littérature sur ce sujet. En effet, rares sont les articles qui sont consacrés aux relations entre les annonces de l'OPEP et les rendements des actions. Nos résultats indiquent que l'OPEP est plus influente pendant les périodes de fortes fluctuations des prix de pétrole avec des disparités spécifiques à chaque industrie.

Depuis plus de vingt ans, les corrélations aussi bien entre les matières premières et les actifs financiers traditionnels et les matières premières et les marchandises elles-mêmes ont significativement évolué. Le chapitre 3 est précisément consacré à l'étude des corrélations entre les différents marchés de matières premières et marchandises. Le but premier de ce chapitre est d'étudier l'influence directe de la financiarisation sur ces marchés,

ainsi que la pérennité de ce phénomène sur le moyen terme. A cet effet, nous utilisons le modèle ADCC à des fins de modélisation des corrélations avec un modèle à changements de régime markovien pour mettre en évidence les cycles d'évolutions de ces corrélations. Cette approche nous permet d'apprécier l'évolution de l'effet de la financiarisation dans le temps. Nos résultats indiquent que la financiarisation a pour conséquence une plus grande intégration des marchés des matières premières et marchandises. De plus, le processus de découverte des prix s'en retrouve altéré et n'est plus indicatif de l'offre et demande réelles de ces marchés.

Plusieurs pistes de recherche sont à envisager pour compléter et enrichir la présente recherche. Dans cette thèse, nous n'avons utilisé que des annonces de l'OPEP pour les chapitres 1 et 2. Cette approche présente l'inconvénient du nombre réduit d'annonces et n'inclut pas le sentiment du marché par rapport aux annonces. En effet, le même type d'annonce peut être interprété comme une « mauvaise » nouvelle, une « bonne » nouvelle ou une nouvelle « neutre » selon l'état du marché comme dans Hervé et al. (2019). Une deuxième piste de recherche serait d'évaluer les corrélations entre les marchés financiers classiques (actions, obligations, entre autres ...) et les marchés des matières premières et des marchandises pour pouvoir apprécier l'impact de la financiarisation sur la capacité de diversification et de couverture de ces marchés. Un exemple de ces études est donné par Andriosopoulos et al. (2017) où les auteurs s'intéressent au phénomène de contagion du marché des obligations vers celui des marchés de matières premières appartenant au sous groupe énergie dans le contexte européen.

# Annexes

## Annexe: Chapitre 2

Maintain results (S&P Global 1200 only)

Table 1.1 CARs around Maintain decisions (1991 Q1-2004 Q4)

Event Day	Building Products	Energy Equipment & Services	Semiconductors & Semiconductor	Technology Hardware, Storage &	Wireless Telecommunication Ser
-5	0.1862	-0.189	-0.096	-0.373	-0.260
-4	0.2078	-0.097	-0.412	-0.462	-0.151
-3	0.5424	-0.136	-0.668	-0.652	-0.174
-2	0.7460	-0.658	-0.990	-0.662	-0.544
-1	1.0254	-0.813	-1.279	-1.260	-1.024
0	1.28 *	-0.811	-1.226	-1.3 *	-1.069
1	1.0330	-0.880	-1.264	-1.253	-1.011
2	0.5348	-0.916	-1.172	-1.5 *	-1.236
3	0.7441	-1.281	-1.2 *	-1.4 *	-1.253
4	0.5268	-1.3 *	-1.022	-1.260	-1.6 *
5	0.5612	-1.061	-0.712	-1.3 *	-1.5 *

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

Table 1.2 CARs around Maintain decisions (2005Q1-2015Q3)

Event Day	Health Care Providers & Servic	IT Services	Life Sciences Tools & Services	Thriffs & Mortgage Finance	Tobacco
-5	0.2435	0.2906	0.1466	0.1976	0.1412
-4	0.4246	0.0235	0.4707	0.3317	0.0615
-3	0.1287	0.0714	0.7436	0.6114	0.2404
-2	0.2803	0.2288	0.9558	0.4005	0.3718
-1	0.7858	0.5241	1.0723	0.1323	0.6462
0	1.1078	0.5636	0.9544	0.3191	1.1615
1	1.29 *	0.2783	0.9754	0.4051	0.9963
2	1.59 *	0.7275	1.0146	0.3240	1.38 *
3	1.6953 **	0.9978	1.0962	0.4006	1.28 *
4	1.59 *	1.29 *	1.34 *	0.7063	1.45 *
5	1.6517 **	1.0327	0.9380	0.4197	1.42 *

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

## Cut results (S&P Global 1200 only)

Table 2.1 CARs around Cut decisions (whole period)

Event Day	Electrical Equipment	Machinery	Road & Rail	Technology Hardware, Storage &	Trading Companies & Distributors
-5	-0.081	-0.199	-0.220	-0.004	0.0020
-4	-0.248	-0.468	-1.086	0.6183	-0.194
-3	-0.713	-0.498	-1.4 *	0.9544	-0.060
-2	-1.110	-1.061	-1.715 **	0.8929	-0.171
-1	-1.3 *	-1.3 *	-1.854 **	0.4946	-0.724
0	-1.248	-1.5 *	-1.4 *	0.6501	-0.887
1	-0.857	-1.5 *	-1.216	0.7722	-0.822
2	-0.645	-1.4 *	-1.017	1.30 *	-0.697
3	-0.655	-1.805 **	-0.621	1.50 *	-1.129
4	-0.957	-1.793 **	-0.876	1.57 *	-1.4 *
5	-0.945	-2.019 **	-0.889	1.8640 **	-1.3 *

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

Table 2.2 CARs around Cut decisions (1991 Q1-2004 Q4)

	Electrical Equipment	Energy Equipment & Services	Household Products	IT Services	Professional Services	Road & Rail	ductors & Semicon	Specialty Retail	Technology Hardware, Storage & Services	Apparel & Luxury	& Mortgage	Companies & Distributors
	-0.113	0.2577	0.1673	-0.278	-0.344	-0.167	-0.170	0.0717	0.0735	0.1432	0.2618	0.0349
	-0.176	0.4001	0.2522	0.0395	-0.127	-0.877	0.1921	0.0910	0.7707	-0.088	0.0735	0.0076
	-0.284	0.7024	0.2491	0.0820	-0.083	-1.195	0.4664	0.2453	1.0377	-0.068	-0.073	0.3082
	-0.569	0.8026	0.3581	0.0524	-0.079	-1.3 *	0.6489	0.5947	1.2404	0.3909	-0.104	0.3045
	-0.836	0.9119	0.1889	-0.441	-0.015	-1.4 *	0.5260	0.7288	1.0276	0.4629	-0.224	-0.359
	-0.992	0.8609	0.0653	-0.096	0.1416	-1.3 *	0.5182	0.9447	0.9500	0.8957	-0.826	-0.577
	-0.674	0.4828	-0.055	-0.166	0.2816	-1.111	1.0225	1.0792	1.1551	0.6848	-1.209	-0.667
	-0.812	0.2485	-0.237	-0.148	0.5377	-0.865	1.48 *	0.8932	1.61 *	0.7560	-0.756	-0.837
	-0.716	0.3645	0.1235	-0.007	0.0094	-0.433	1.7351 **	1.37 *	2.0007 **	0.6595	-0.646	-1.3 *
	-1.141	0.5043	-0.125	-0.383	-0.276	-0.463	1.58 *	1.40 *	2.0240 **	0.7393	-0.367	-1.5 *
	-1.021	0.1211	-0.218	-0.676	-0.241	-0.593	1.6910 **	1.0368	2.3281 ***	0.3672	-0.106	-1.4 *

Event Day	Aerospace & Defense	Banks
-5	-0.179	-0.284
-4	-0.260	0.1942
-3	-0.597	0.0135
-2	-0.757	-0.209
-1	-0.935	-0.055
0	-1.079	-0.378
1	-0.890	-0.635
2	-1.208	-0.695
3	-1.4 *	-0.509
4	-1.085	-0.314
5	-1.019	-0.042

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

Table 2.3 CARs around Cut decisions (2005Q1-2015Q3)

	Road & Rail	ductors & Semicon	Software	Specialty Retail	ogy Hardware, Consumer Electronics	Apparel & Luxury	& Mortgage	Tobacco	Companies & Distri	Water Utilities	Wireless Telecommunications
	-0.391	-0.549	-0.398	0.0593	-0.655	0.2687	-0.495	0.0649	-0.155	-1.3 *	0.8968
	-1.697 **	-0.914	-1.271	-1.255	-0.666	-0.878	-1.852 **	0.0299	-0.945	-0.597	1.6793 **
	-2.258 **	-0.787	-1.807 **	-1.045	-0.645	-0.930	-1.734 **	0.0053	-1.4 *	-1.001	0.9647
	-2.642 ***	-1.5 *	-2.753 ***	-1.799 **	-1.693 **	-2.068 **	-1.872 **	0.3992	-1.822 **	-1.151	1.39 *
	-2.971 ***	-2.747 ***	-3.137 ***	-2.543 ***	-2.699 ***	-2.525 ***	-1.931 **	0.3067	-1.919 **	0.7419	1.8386 **
	-1.195	-1.5 *	-3.283 ***	-2.082 **	-0.966	-2.199 **	-2.131 **	0.1235	-1.939 **	0.0267	1.33 *
	-1.178	-1.229	-2.637 ***	-1.832 **	-0.828	-1.898 **	-2.304 **	0.5529	-1.5 *	0.3357	1.8766 **
	-1.080	-0.632	-0.552	-0.271	-0.070	-1.034	-1.5 *	1.1675	-0.187	2.6548 ***	1.8908 **
	-0.850	-1.811 **	-2.716 ***	-2.015 **	-0.750	-1.712 **	-1.3 *	0.6353	-0.519	1.8972 **	2.7687 ***
	-1.885 **	-1.850 **	-3.115 ***	-1.4 *	-0.250	-3.050 ***	-2.639 ***	0.7023	-1.088	2.0642 **	3.7890 ***
	-1.5 *	-2.362 ***	-4.385 ***	-0.968	-0.033	-3.008 ***	-2.776 ***	0.0022	-1.138	2.1590 **	2.9193 ***



Care Provider	Health Care Technology	Hotels Restaurants & Lodging	Household Durable Goods	Household Products	Industrial Conglomerates	IT Services	Leisure Products	Life Sciences Tools & Equipment	Machineery	Media	Multi-Utilities	Multiple Retail	& Consumable	Paper & Forest Products	Personal Products	Professional Services	Estate Investment
-0.579	0.0169	0.7183	-1.194	0.3018	-0.420	-0.898	-0.875	-0.475	-0.256	-0.594	-0.450	-0.127	1.28 *	0.1311	-2.699 ***	-0.194	-0.160
-0.299	0.1678	-1.091	-1.945 **	0.1639	-1.6 *	-0.693	-3.410 ***	-0.400	-1.215	-1.3 *	1.0709	-1.246	2.2532 **	-0.350	-2.945 ***	-0.917	-2.093 **
0.2267	-0.172	-0.658	-1.716 **	-0.103	-0.247	-0.257	-3.154 ***	-0.668	-1.4 *	-1.957 **	1.2293	-0.530	2.0131 **	-0.471	-3.354 ***	-0.568	-1.4 *
0.1199	-0.649	-1.4 *	-1.980 **	-0.080	0.3135	-1.5 *	-4.003 ***	0.7765	-2.902 ***	-2.806 ***	1.0461	-1.3 *	1.34 *	-0.484	-3.534 ***	-0.331	-2.260 **
-1.121	-1.204	-1.3 *	-2.152 **	0.0255	1.1429	-1.5 *	-4.287 ***	1.1686	-3.899 ***	-2.044 **	2.0502 **	-2.197 **	1.9717 **	-0.005	-3.193 ***	-0.642	-0.982
-0.785	-0.562	-0.970	-2.803 ***	-0.350	1.2407	-1.159	-3.318 ***	0.9508	-4.461 ***	-2.936 ***	1.35 *	-1.718 **	2.0399 **	0.2758	-1.685 **	0.4966	-1.007
-0.805	-1.3 *	-0.749	-2.223 **	-0.039	2.3388 ***	0.1061	-2.832 ***	0.5414	-4.160 ***	-2.899 ***	1.8049 **	-0.280	1.1411	0.5842	-3.285 ***	2.2584 ***	-2.830 ***
-0.648	-1.808 **	1.39 *	-2.784 ***	-0.474	2.5880 ***	1.6527 **	-1.5 *	0.6959	-3.011 ***	-1.033	3.1388 ***	-0.327	1.1614	1.53 *	-1.811 **	3.0411 ***	-0.176
-2.062 **	-1.907 **	1.63 *	-3.267 ***	0.2934	0.9822	-0.651	-2.504 ***	1.2591	-4.725 ***	-2.363 ***	2.3883 ***	-1.789 **	1.0590	1.2332	-2.249 **	0.5140	-0.999
-1.806 **	-2.408 ***	1.6460 **	-3.795 ***	0.1145	0.2248	0.1076	-2.848 ***	1.43 *	-4.584 ***	-2.772 ***	1.9914 **	-2.334 ***	1.1283	1.46 *	-2.081 **	0.5133	-0.469
-0.407	-1.913 **	1.8969 **	-3.592 ***	0.3543	0.7828	0.9815	-2.366 ***	1.8426 **	-5.087 ***	-1.861 **	0.6474	-1.273	1.39 *	1.60 *	-3.178 ***	0.6244	-0.471

Auto Components	Automobiles	Banks	Building Products	Chemicals	Commercial Services & Equipment	Construction & Engineering	Construction Material	Containers & Packaging	Food Consumer	Electric Utilities	Electrical Equipment	Electronic Equip., Instrument	Energy Equipment & Construction	Food & Staples Retailing	Food Products	Gas Utilities
-0.406	-0.330	-0.890	-2.010 **	-0.034	-0.351	-1.2 *	-0.020	0.5633	0.0194	-0.748	-0.066	-0.626	0.1494	-0.517	0.0600	-0.242
-2.330 ***	-1.5 *	-2.182 **	-1.966 **	0.2020	-0.400	0.2260	-0.369	1.2258	-0.826	0.5299	-0.537	-1.102	0.7087	-0.303	-0.092	1.1380
-2.048 **	-1.161	-1.652 **	-3.682 ***	0.7684	-0.414	0.0574	-0.742	1.52 *	-0.514	0.9156	-2.273 **	-0.432	0.8736	-0.882	0.5596	1.34 *
-3.100 ***	-2.404 ***	-1.803 **	-3.837 ***	-0.044	-0.103	-0.670	-1.977 **	1.39 *	-1.3 *	0.4794	-2.885 ***	-1.3 *	0.0883	-1.098	1.35 *	1.43 *
-2.855 ***	-2.581 ***	-1.968 **	-4.255 ***	0.8103	1.2193	-0.657	-0.839	1.8229 **	-1.065	2.0207 **	-3.176 ***	-1.887 **	0.7894	-0.709	1.33 *	2.7735 ***
-2.614 ***	-2.977 ***	-2.392 ***	-4.648 ***	0.6206	1.9917 **	-1.135	-2.105 **	1.7904 **	-1.274	1.2810	-1.971 **	-2.237 **	0.7335	-0.453	0.8776	2.1973 **
-3.143 ***	-3.112 ***	-1.3 *	-5.472 ***	-0.069	3.0764 ***	0.1494	-1.857 **	1.6904 **	-1.721 **	1.55 *	-1.2 *	-2.059 **	-0.324	-0.354	1.0071	2.1868 **
-1.4 *	-1.755 **	-0.340	-4.710 ***	0.3747	5.3509 ***	0.6764	-2.112 **	3.3387 ***	-0.213	2.8508 ***	0.0799	-0.002	-0.206	-0.357	0.4541	2.6131 ***
-2.753 ***	-1.4 *	-1.179	-4.610 ***	-0.479	3.3395 ***	-0.265	-2.429 ***	1.8019 **	-1.879 **	2.7994 ***	-0.360	-1.088	0.4272	-1.074	-0.836	2.8122 ***
-2.732 ***	-2.130 **	-1.6 *	-5.129 ***	-0.540	3.6098 ***	-0.300	-3.315 ***	1.7288 **	-2.213 **	2.7613 ***	-0.095	-0.732	0.4484	-0.899	-1.5 *	3.3222 ***
-1.3 *	-2.101 **	-1.094	-4.490 ***	-0.670	4.1909 ***	-0.086	-2.524 ***	1.7655 **	-1.892 **	2.1675 **	-0.494	-1.045	0.0835	-0.098	-1.916 **	3.3028 ***

Event Day	Aerospace & Defense	Freight & Logistic	Airlines
-5	-1.209	-0.393	-1.4 *
-4	-1.754 **	-0.395	-1.5 *
-3	-1.3 *	-1.3 *	-0.589
-2	-1.713 **	-1.724 **	-0.457
-1	-1.4 *	-0.730	-0.297
0	-1.4 *	-0.877	0.2291
1	-0.753	-1.261	0.4839
2	1.2274	-0.529	0.5193
3	0.5278	-1.3 *	-0.238
4	0.0921	-1.948 **	0.1905
5	0.8260	-1.889 **	-0.015

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

## Increase (S&P Global 1200 only)

Table 3.1 CARs around Increase decisions (whole period)

Event Day	Biotechnology	Building Products	Electric Utilities	IT Services	Media	Multi-Utilities	Multiline Retail	Specialty Retail	Technology Hardware, Storage &	Thriffs & Mortgage Finance
-5	-0.009	-9.105	0.0703	0.1875	0.3576	0.0149	0.3752	0.3298	0.0900	0.1091
-4	0.3129	0.0015	0.3882	0.8112	0.6190	0.4348	0.7054	0.9339	0.6999	-0.020
-3	0.6965	-0.089	0.7756	0.6854	0.9342	0.6806	1.1281	1.36 *	0.9298	0.2886
-2	1.0024	0.0511	0.8200	1.1784	1.1447	0.7915	1.33 *	1.43 *	1.29 *	-1.6 *
-1	1.1921	-0.546	1.0377	1.33 *	1.1977	1.0734	1.2324	1.49 *	1.0825	-1.6 *
0	1.2458	-0.663	1.0809	1.2317	1.0212	1.1228	1.38 *	1.29 *	1.0852	-1.920 **
1	1.42 *	-0.872	1.1424	1.29 *	1.32 *	1.2281	1.39 *	1.2576	0.9810	-1.913 **
2	1.1865	-1.038	1.31 *	1.1013	1.1666	1.46 *	1.39 *	1.0362	0.5509	-2.103 **
3	1.28 *	-1.4 *	1.1339	0.9294	0.8216	1.31 *	1.0967	0.7813	0.2932	-2.305 **
4	1.2543	-1.4 *	1.0260	1.1170	0.8210	1.1662	1.44 *	1.0472	0.3000	-2.671 ***
5	0.8618	-1.887 **	0.8524	0.7924	0.7307	0.9022	1.29 *	0.7373	0.2657	-2.623 ***

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

Table 3.2 CARs around Increase decisions (1991 Q1- 2004 Q4)

IT Services	Media	Multi-Utilities	Multiline Retail	Personal Products	Specialty Retail
0.1613	0.5076	0.1038	0.5735	0.3037	0.3883
0.7324	0.8625	0.5211	1.0030	0.1161	1.1218
0.5254	1.2314	0.8117	1.2579	0.2087	1.62 *
0.9818	1.51 *	0.8305	1.32 *	0.4098	1.61 *
1.2759	1.6661 **	1.28 *	1.1533	0.9945	1.6486 **
1.1989	1.6898 **	1.30 *	1.32 *	1.1713	1.36 *
1.33 *	2.0826 **	1.37 *	1.43 *	1.8202 **	1.50 *
1.38 *	2.1222 **	1.7531 **	1.6626 **	1.63 *	1.43 *
1.1666	1.8301 **	1.52 *	1.2765	1.8269 **	1.0609
1.2680	1.6705 **	1.33 *	1.63 *	2.1643 **	1.28 *
1.0799	1.56 *	1.1460	1.41 *	1.8115 **	0.9679

Event Day	Airlines	Banks	Biotechnology	Electric Utilities	Gas Utilities	Industrial Conglomerates
-5	0.2597	-0.010	-0.151	0.1921	0.2466	-0.302
-4	0.7417	0.1294	0.0807	0.5646	0.5029	0.1349
-3	0.8363	0.1909	0.4997	1.1059	1.0658	0.4595
-2	0.7080	0.5745	0.7199	1.0960	0.9322	0.1357
-1	1.2548	0.7962	0.9923	1.35 *	1.0756	-0.224
0	1.36 *	0.7938	1.1537	1.49 *	1.43 *	-0.088
1	1.41 *	1.1410	1.29 *	1.51 *	1.6605 **	-0.000
2	1.7864 **	1.33 *	0.9817	1.8571 **	1.7050 **	0.3448
3	1.46 *	1.1722	0.9281	1.6935 **	1.0973	0.0138
4	1.53 *	1.0272	0.8841	1.53 *	0.8832	-0.002
5	1.1436	1.0748	0.6908	1.45 *	1.0972	-0.405

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

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\*\* indicates the t-statistic is significant at 5% level.

\*\*\* indicates the t-statistic is significant at 1% level.

Table 3.2 CARs around Increase decisions (2005 Q1- 2015 Q3)

Software	Specialty Retail	Consumer Electronics	Apparel & Luxury	& Mortgage	Tobacco	Companies & Distri	Water Utilities	Telecommunications
-0.234	0.2422	0.0171	1.29 *	0.3069	0.0809	-0.494	-0.345	0.3684
0.5010	0.5219	0.6125	1.7480 **	0.1281	-0.093	0.0759	-0.304	0.5015
0.0923	0.6020	0.5049	1.8684 **	0.3870	-0.291	0.1291	-0.702	0.3848
0.5340	1.0402	0.2985	1.7939 **	-5.481 ***	-0.499	0.4864	-0.107	0.6052
0.6351	1.1751	-0.628	1.9656 **	-5.331 ***	-0.852	0.7113	-0.338	0.8343
0.6293	1.0933	-0.010	1.9951 **	-6.580 ***	-1.181	1.1976	-0.511	-0.177
0.9169	0.7057	-0.623	2.1079 **	-7.049 ***	-1.176	1.7799 **	0.0894	-0.558
0.5434	0.0508	-1.820 **	1.8030 **	-8.000 ***	-1.278	1.39 *	-0.450	-0.972
1.1302	0.3195	-1.6 *	1.8769 **	-8.264 ***	-1.3 *	2.1701 **	-0.314	-1.779 **
1.2797	0.5357	-0.776	1.9801 **	-9.275 ***	-1.253	2.2002 **	0.3586	-0.474
0.7265	0.3529	-1.258	1.62 *	-8.894 ***	-0.749	3.2884 ***	0.2591	-0.204

Household Durable	Household Products	Industrial Conglomerates	IT Services	Leisure Products	Life Sciences Tools & Services	Machine ry	Media	Metals & Mining	Multi-Utilities	Multiple Retail	& Consumable	Paper & Forest Products	Personal Products	Pharmaceuticals	Professional Services	Estate Investment	ductors & Semicon
-0.198	-0.357	0.0189	0.2907	-0.163	0.1364	-0.174	0.2266	-0.235	-0.200	-0.062	0.3911	0.7431	-0.164	0.0581	-0.802	0.0997	-0.005
-0.594	0.0602	-0.247	0.9538	-0.306	0.5443	-0.069	0.4472	-0.582	0.2582	0.1346	0.6947	0.5114	0.0654	0.1708	-0.351	-0.109	1.0672
-0.388	0.0878	-0.029	0.8002	-0.227	0.3575	0.4317	0.5957	0.4674	0.2125	1.0152	1.29 *	0.9715	-0.652	-0.697	-0.183	-0.233	0.6846
0.0802	0.3988	0.2468	1.48 *	-0.146	-0.616	-0.263	0.8382	-0.886	0.7536	1.7567 **	0.2798	1.6543 **	-0.781	-0.733	-0.306	0.1710	0.3717
-0.426	0.4530	0.2524	1.1129	-0.174	-0.345	-0.795	0.7346	-1.853 **	0.5486	1.8283 **	-0.743	1.35 *	-0.681	-1.154	-0.336	-0.203	0.0409
-0.168	0.5301	0.0610	0.6706	-0.678	-0.234	-0.625	-0.143	-1.185	0.5786	1.8553 **	0.3259	1.42 *	-0.827	-1.233	-1.090	0.1833	-0.030
-0.018	0.0668	0.5317	0.6705	-0.226	-0.273	-0.594	0.2257	-0.497	0.8527	1.7808 **	1.1891	1.7629 **	-0.885	-1.241	-0.990	0.6999	-0.287
-0.071	-0.097	0.4191	-0.432	-0.565	-0.072	-0.870	-0.405	-0.103	0.6211	1.2112	1.7901 **	1.47 *	-0.803	-1.689 **	-0.914	0.5306	-1.088
0.3604	0.3068	1.1789	-0.208	-0.469	-0.269	-0.396	-0.814	-0.434	0.9381	1.29 *	1.53 *	0.9998	-0.493	-2.013 **	-1.083	0.1708	-1.221
1.56 *	0.4264	2.2366 **	-0.025	0.0659	0.1900	0.9048	-0.640	0.0520	0.8291	1.47 *	1.57 *	2.6933 ***	-0.882	-1.958 **	-1.240	0.4845	-0.476
1.57 *	-0.055	2.3298 ***	-0.718	0.5139	-0.151	0.8971	-0.634	0.2052	0.3719	1.6774 **	1.36 *	1.8527 **	-0.967	-1.654 **	-1.172	0.2467	0.0604

Building Products	Chemicals	Medical Services & Equipment	Construction & Engineering	Construction Material	Containers & Packaging	Food Consumer	Electric Utilities	Medical Equip., Instrument	Food Staples & Retail	Food Products	Gas Utilities	Care Equipment	Care Providers	Health Care Technology	Hotels Restaurants & Lodging
0.3575	0.6618	-0.177	-0.227	0.3376	-0.012	0.3254	-0.119	0.3051	0.2443	-0.539	-0.753	0.1357	-0.505	0.0232	0.3349
0.4274	1.1043	-0.242	-1.065	1.54 *	-0.642	0.7765	0.1645	0.2946	0.1197	-0.838	-0.225	-0.036	-0.055	-0.151	0.7354
0.3535	1.63 *	-0.286	-0.182	1.49 *	0.0175	0.7124	-0.035	0.5868	0.1268	-1.002	-0.334	0.1220	0.1947	0.1522	1.0996
0.9539	1.31 *	0.1230	-0.951	1.49 *	0.1834	0.8554	0.4637	0.0808	0.2380	-1.048	0.1327	0.2568	0.2195	0.1372	1.51 *
0.9893	0.8983	0.5765	-1.699 **	1.9325 **	-0.639	0.5361	0.7026	-0.263	0.5505	-0.796	-0.377	0.3730	0.5668	0.0752	1.9439 **
1.1670	0.7162	-0.060	-0.806	1.8940 **	-0.418	0.1562	0.3336	0.7093	0.6340	-0.976	-0.165	0.3288	-0.055	0.0714	1.39 *
1.2185	1.29 *	0.4539	0.0416	1.30 *	0.4537	-1.5 *	0.6933	0.6106	0.7465	-0.729	0.5079	0.1926	-0.368	0.2317	1.62 *
1.1728	1.1266	-0.241	0.6753	2.5582 ***	0.5090	-1.664 **	0.4696	0.4086	0.3120	-1.098	0.5260	-0.192	-1.022	0.1072	0.9426
1.1103	1.37 *	0.2097	1.0272	2.0043 **	0.6640	-0.962	0.5680	1.35 *	0.7152	-1.3 *	-0.023	0.1302	-1.235	-0.139	0.4925
1.6825 **	2.1177 **	-0.091	1.7778 **	2.5750 ***	1.0604	-0.354	0.4246	2.1985 **	1.2019	-1.140	0.3480	0.3291	-0.770	-0.327	1.40 *
1.6479 **	1.9857 **	0.3044	2.3783 ***	1.1179	-0.393	-0.331	0.1154	2.5218 ***	0.8356	-1.272	0.0620	0.6718	-0.533	-0.368	1.30 *

Event Day	Aerospace & Defense	Airlines	Auto Components	Automobiles	Banks	Beverages	Biotechnology
-5	-0.269	0.2326	0.4607	0.5209	0.2923	-0.094	0.4512
-4	-0.096	0.1052	0.9595	0.8327	0.3274	0.2864	1.1220
-3	0.2593	0.6776	1.32 *	0.6492	1.1227	0.3665	1.43 *
-2	-0.174	0.3629	1.2172	-0.092	1.8940 **	0.2362	1.9640 **
-1	0.3560	0.4378	0.7041	0.1466	1.7317 **	0.7402	1.9022 **
0	0.0224	-0.124	-0.264	-0.159	1.36 *	0.4007	1.6622 **
1	0.1526	0.1930	0.1874	-0.308	1.7230 **	0.8925	2.1086 **
2	-0.288	-0.379	0.3650	-1.001	2.0521 **	0.5527	2.1779 **
3	0.0987	0.2222	0.8582	-0.358	2.3581 ***	0.5933	2.8036 ***
4	0.4372	0.8508	1.0605	-0.186	3.3424 ***	0.3670	2.8304 ***
5	-0.552	1.0802	1.2233	0.5294	3.4774 ***	0.0991	1.8838 **

Note:

Some of the displayed sectors do not show significance but are significant when MSCI ACWI is used.

\*indicates the t-statistic is significant at 10% level.

\*\*indicates the t-statistic is significant at 5% level.

\*\*\*indicates the t-statistic is significant at 1% level.

## Annexe : Chapitre 3

Table 1. Constant Markov transition probabilities and expected durations for the Industrial Metals- Energy pair

Date: 11/20/19 Time: 12:38

Transition summary: Constant Markov transition probabilities and expected durations

Sample: 1/14/2000 4/26/2018

Included observations: 6678

Constant transition probabilities:

$P(i, k) = P(s(t) = k \mid s(t-1) = i)$

(row = i / column = j)

	1	2
1	0.474158	0.525842
2	4.95E-06	0.999995

Constant expected durations:

	1	2
1	1.901711	202012.1

Table 2. Constant Markov transition probabilities and expected durations for the Precious Metals-Energy pair

Date: 11/20/19 Time: 11:34

Transition summary: Constant Markov transition probabilities and expected durations

Sample: 1/14/2000 4/26/2018

Included observations: 6678

Constant transition probabilities:

$P(i, k) = P(s(t) = k \mid s(t-1) = i)$

(row = i / column = j)

	1	2
1	0.992240	0.007760
2	0.352667	0.647333

Constant expected durations:

	1	2
1	128.8583	2.835537



Table 3. Constant Markov transition probabilities and expected durations for the Agriculture-Energy pair

Date: 11/20/19 Time: 10:53

Transition summary: Constant Markov transition probabilities and expected durations

Sample: 1/14/2000 4/26/2018

Included observations: 6678

Constant transition probabilities:

$P(i, k) = P(s(t) = k | s(t-1) = i)$

(row = i / column = j)

	1	2
1	0.944158	0.055842
2	0.041891	0.958109

Constant expected durations:

	1	2
	17.90763	23.87158

Table 4. Constant Markov transition probabilities and expected durations for the Industrial Metals-Agriculture pair

Date: 11/20/19 Time: 10:53

Transition summary: Constant Markov transition probabilities and expected durations

Sample: 1/14/2000 4/26/2018

Included observations: 6678

Constant transition probabilities:

$P(i, k) = P(s(t) = k | s(t-1) = i)$

(row = i / column = j)

	1	2
1	0.952429	0.047571
2	0.457790	0.542210

Constant expected durations:

	1	2
	21.02117	2.184406

Table 5. Constant Markov transition probabilities and expected durations for the Precious Metals-Agriculture pair

Date: 11/20/19 Time: 10:31

Transition summary: Constant Markov transition probabilities and expected durations

Sample: 1/14/2000 4/26/2018

Included observations: 6678

Constant transition probabilities:

$P(i, k) = P(s(t) = k | s(t-1) = i)$

(row = i / column = j)

	1	2
1	0.995217	0.004783
2	0.003086	0.996914

Constant expected durations:

	1	2
	209.0835	324.0590

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