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Three Essays on Commodity Prices

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Three Essays on Commodity Prices

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Dedicatoria

Hace cuatro años emprendí un camino de aprendizaje en todos los sentidos de mi vida, este documento sólo representa el resultado de una parte de ellos. Es por esto que quiero dedicar esta tesis a Fernando, mi marido, por emprender este camino conmigo, por su paciencia, y por cuidar bien a nuestros bebés durante mi ausencia. No hubiera podido culminar este ciclo de aprendizaje sin su continuo apoyo y amor. A mi madre, María Eugenia, y a mi suegra, Graciela, que apartaron meses de sus vidas para acompañar a mi familia en momentos difíciles, gracias.

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Content

Introducción

La presente tesis está compuesta por el desarrollo de tres trabajos de investigación cuyos resultados pueden ser leídos de manera independiente. Los tres incluyen temas relacionados con la evolución de los precios de las materias primas: sus características y determinantes a nivel internacional, el reciente papel de la incertidumbre en el mercado, el poder predictivo del movimiento conjunto de los precios de las materias primas en el tiempo y las posibles vías por las que dicha evolución afecta la economía de un país dependiente de los productos básicos como Colombia.

La evolución de los precios de las materias primas afecta de una u otra manera la economía de un país debido a que los bienes de uso cotidiano están relacionados con las materias primas, desde la gasolina que da energía a los barcos y camiones que transportan productos, hasta el cobre en el cableado eléctrico y los alimentos consumidos. Las fluctuaciones en los precios de los productos son de especial relevancia para las economías dependientes de materias primas, no sólo porque representan una gran proporción de las exportaciones totales sino también porque una gran cantidad de ingresos fiscales provienen a menudo de este sector. En este sentido choques en los precios de las materias primas exportadas pueden generar una mayor vulnerabilidad de estos países en términos comerciales y también pueden producir una política fiscal pro-cíclica si el país no se encuentra suficientemente diversificado a nivel de exportaciones y a nivel tributario.

Adicionalmente la evolución de los precios de las materias primas está directamente relacionada con la inflación, por lo tanto, países importadores de materias primas también pueden verse afectados por fuertes movimientos en los precios. Así, periodos de auge como el acontecido entre los años 2007 y 2008, puede por un lado dificultar la política monetaria en los países desarrollados y por otro llevar a niveles más altos de pobreza en países pobres, debido a que gran parte de los ingresos de los hogares en estos países se utiliza para la compra de alimentos.

En vista de la importancia de los precios de los productos básicos para muchos países en el mundo, es relevante conocer las fuerzas que impulsan el movimiento internacional de sus precios; la forma de mejorar la capacidad de predicción en los precios de las materias primas; y los mecanismos por los cuales las fluctuaciones en los precios de las materias primas puede afectar a las economías dependientes, como Colombia.

En esta introducción se presenta un breve resumen de los capítulos presentados en la tesis, poniendo especial énfasis en la motivación y la contribución de cada uno de ellos. El resto de la tesis se encuentra organizada de la siguiente manera: Los capítulos 2, 3 y 4 contienen los trabajos de investigación de la tesis. El capítulo 5, el cual contiene las conclusiones, se divide en tres apartados: El primero, denominado Conclusiones Generales redondea los principales resultados de la tesis en su conjunto; En el segundo apartado, denominado Desarrollos Futuros se evalúan nuevas líneas de investigación derivadas de la tesis; finalmente, en el apartado Difusión de Resultados se enumeran los congresos y seminarios en los que han sido presentados los resultados de la investigación, así como las publicaciones resultantes de ellos y los premios recibidos.

Trabajos de investigación de la tesis

En este apartado se ofrece una síntesis de los próximos capítulos de la tesis, en particular se presenta en detalle los objetivos de la investigación y los principales hallazgos y aportaciones en cada uno de ellos.

Capítulo 2. Dinámica conjunta en los precios de las materias primas no energéticas y su relación con la incertidumbre.

El propósito de este capítulo consiste en mejorar la evidencia empírica sobre los precios de los productos básicos en varios aspectos. En primer lugar, se trata de identificar la importancia de los movimientos sincronizados de 44 series de precios de productos básicos con frecuencia mensual. El objetivo es determinar si la evolución conjunta de los precios de diferentes materias primas no energéticas ha incrementado desde finales del año 2003 como consecuencia de la llamada financialización de los mercados de materias primas. La financialización en el mercado de materias primas hace referencia a dos fenómenos relacionados: primero, el aumento desmesurado de inversiones destinadas a los índices de materias primas y, segundo, al incremento en el número de operadores financieros especulativos en este mercado a partir de finales del año 2003. La hipótesis planteada radica en la idea que el proceso de financialización puede transformar la determinación de los precios en el mercado de productos básicos en el corto plazo. Por lo tanto, como resultado de este fenómeno los precios de las materias primas en su conjunto se asemejan más, en el corto plazo, al precio de un activo especulativo, como las acciones y divisas. De acuerdo con ello, y sin dejar de lado la importancia de los factores macroeconómicos a nivel internacional, la financialización de los mercados de productos básicos puede conducir a una creciente importancia de variables especulativas en la determinación de precios de las materias primas no energéticas.

El segundo objetivo del artículo consiste en evaluar tanto la importancia relativa de variables macroeconómicas fundamentales como la de variables financieras en la determinación del movimiento conjunto entre los precios de materias primas no energéticas en el corto plazo. Es importante destacar que se evalúa el papel de la incertidumbre de mercado como un nuevo posible determinante de la evolución común de los precios. Se utilizan datos mensuales desde febrero de 1992 hasta diciembre de 2012 y se divide la muestra en dos períodos (previo y posterior a diciembre de 2003) con el fin de evaluar si la importancia relativa de variables financieras como el precio de las acciones y la incertidumbre del mercado cambia en el período de financialización (posterior a Diciembre de 2003).

En relación a la metodología, se diagnostica el movimiento conjunto en los precios utilizando un modelo factorial dinámico estimado por Componentes Principales. Adicionalmente, se estima un modelo que combina los resultados actuales del análisis factorial dinámico con los modelos de vectores autoregresivos (FAVAR, por sus siglas en inglés) propuesto por Bernanke, Boivin y Eliasz (2005). La estimación del modelo FAVAR tiene como objetivo medir las relaciones dinámicas entre las variables macroeconómicas a nivel internacional, o fundamentos, y las variables financieras con el movimiento conjunto en los precios de las materias primas. Se presentaron los resultados de las funciones de impulso respuesta y la descomposición de la varianza del factor no energético del modelo FAVAR. Los resultados del primero permiten rastrear los efectos en el tiempo en los precios de las materias primas no energéticas ante choques exógenos de las otras variables. Los resultados de la descomposición de varianza muestran la importancia relativa de cada una de las variables en la determinación del precio conjunto de las materias primas no energéticas.

Las conclusiones de este segundo capítulo se resumen a continuación. En primer lugar, se encontró una mayor sincronización entre los precios de las materias primas a partir de diciembre de 2003, como se sugiere en la hipótesis de financialización. Más precisamente, la varianza en los precios de las materias primas explicada por el comportamiento común de los precios de los productos básicos se incrementó de 9 % entre febrero de 1992 y noviembre de 2003, a 23 % entre diciembre de 2003 y diciembre de 2012. Esto significa que después de 2004 el comportamiento común de los precios de las materias primas tiene un peso mayor en las fluctuaciones de los precios en comparación con el período anterior a la financialización, es decir, antes de 2004.

En segundo lugar, el análisis impulso-respuesta en el modelo FAVAR indica que los choques en el índice bursátil así como en la incertidumbre de mercado afectan significativamente los precios de los productos básicos no energéticos sólo después de finales de 2003. Un choque positivo en el mercado de valores es seguido por un incremento en los precios de las materias primas no energéticas, lo cual muestra un mayor vínculo entre los mercados para el segundo sub-período. En relación con los efectos de la incertidumbre, se encontró que un aumento en esta variable conduce a una disminución de los precios de las materias primas no energéticas, lo que significa que los inversores reaccionan vendiendo activos en materias primas ante aumentos en la incertidumbre.

En tercer lugar, el análisis de descomposición de la varianza en el modelo FAVAR muestra que la incertidumbre juega un papel relevante en la explicación de la fluctuación no energética sólo en el segundo periodo. En particular, el porcentaje de la varianza del error de predicción del factor no energético a un horizonte de 12 meses que es atribuible a un choque en la incertidumbre, pasó de menos del 5% en el primer periodo, a 17,4% en el segundo. De hecho, a partir de esta fecha los choques de incertidumbre representan una mayor proporción en la descomposición de varianza de los precios de las materias primas no energéticas que otras variables macroeconómicas que previamente tuvieron un mayor peso, tales como la tasa de cambio real y la demanda mundial. Lo anterior pone de relieve la creciente importancia de la incertidumbre como un determinante de las comunalidades en las materias primas no energéticas.

La contribución más importante de este capítulo a la literatura radica en la determinación del papel de la incertidumbre en la formación de los precios de las materias primas no energéticas en un contexto de corto plazo. Existen pocos estudios que analizan este tema en general, y ninguno que evalúe el papel de la incertidumbre en un contexto de corto plazo y especulativo, por lo tanto, el artículo llena este vacío. Por otra parte, teniendo en cuenta que se divide el período muestral para tener en cuenta la fecha de inicio de la financialización, el estudio comprueba que el movimiento conjunto en los precios de las materias primas no energéticas ha sido recientemente más afectado por variables especulativas. Otras aportaciones de la tesis a la literatura de movimiento conjunto en los precios de las materias primas no energéticas son: el uso de datos de más alta frecuencia que los utilizados anteriormente en la literatura en el modelo FAVAR y el uso de una variable que no ha sido utilizada previamente en el estudio de la incertidumbre en los precios de los productos básicos: el Chicago Board Options Exchange Volatility Index (VIX), la cual tiene en cuenta la volatilidad esperada en el mercado futuro. Se prueba la robustez de los resultados utilizando otras medidas de incertidumbre como el índice de incertidumbre de Política Económica y el Índice bursátil de Incertidumbre construido por Baker, Bloom y Davis (2013) que tampoco han sido utilizados en el pasado, según refiere la literatura del tema.

Capítulo 3. Análisis del contenido predictivo del movimiento conjunto en la inflación de los precios de las materias primas no energéticas.

Este capítulo se deriva de los hallazgos encontrados en el capítulo anterior. Específicamente existen dos resultados que motivaron esta investigación. En primer lugar, se encontró que el movimiento conjunto entre diferentes precios no energéticos aumenta a partir de finales del año 2003. Adicionalmente, en este periodo existe una gran fracción del movimiento de los precios de los productos básicos que no es atribuible a variables macroeconómicas fundamentales. Por lo tanto, un objetivo de este artículo es explorar si el movimiento conjunto entre los precios de materias primas no energéticas, tiene algún contenido predictivo sobre la inflación de los precios de las materias primas.

Por otra parte, el artículo también tiene como objetivo evaluar qué grado de comunalidad tiene un mejor desempeño a nivel de predicción: un movimiento conjunto de gran escala, que comprende la evolución común de una amplia gama de precios de las materias primas no energéticas, o un movimiento conjunto de pequeña escala, el cual contiene el patrón común de los precios de las materias primas dentro de la misma categoría. Adicionalmente, el artículo explora si la predictabilidad de los precios de los productos varía a través de las diferentes categorías.

Se utiliza la base de datos del Fondo Monetario Internacional que comprende los precios mensuales de 44 materias primas no energéticas divididas en las categorías: cereales, carnes y mariscos, bebidas, aceite vegetal y harinas proteicas, materias primas agrícolas y metales. Metodológicamente se utiliza un Modelo Factorial Dinámico (DFM, por sus siglas en inglés) para extraer el movimiento conjunto de la inflación en los precios de las materias primas no energéticas. Se utilizan dos métodos de estimación dentro del enfoque DFM: componentes principales para extraer la evolución común de todo el conjunto de datos de precios de productos básicos, y el filtro de Kalman para extraer los factores latentes dentro de las categorías. La idea básica consiste en tomar el factor extraído, estimado ya sea por componentes principales o por el filtro de Kalman, y utilizarlo para predecir la inflación de las materias primas no energéticas. Adicionalmente, se estima un modelo autoregresivo (AR, por sus siglas en inglés), y un modelo de caminata aleatoria (RW, por sus siglas en inglés), este último utilizado como referencia. Dentro del procedimiento econométrico se contempla la comparación de los diferentes modelos mediante la evaluación de los pronósticos fuera de muestra. Esta comparación se lleva a cabo mediante el ratio de la raíz cuadrada del error cuadrático medio (RMSE, por sus siglas en inglés) de predicción entre los pronósticos de los modelos estimados un periodo hacia adelante y aquellos generados por una caminata aleatoria. Se toman datos desde enero de 2004 hasta diciembre de 2013, siendo 2011:01 - 2013:12 el período de evaluación.

Las principales conclusiones del artículo se presentan a continuación. En términos generales se encontraron resultados prometedores en los modelos factoriales dinámicos estimados por medio del filtro de Kalman, los cuales tienen en cuenta el movimiento conjunto por categoría de materias primas. Específicamente, los resultados muestran una capacidad predictiva superior frente a los pronósticos generados por la caminata aleatoria en las categorías metales, aceites vegetales y harinas proteicas. Este resultado, a su vez, contrasta con la baja capacidad predictiva encontrada en el modelo factorial dinámico, estimado por medio de componentes principales, el cual toma en cuenta la evolución conjunta en la totalidad de las series de precios de las materias primas. Además, en el capítulo se sugiere que el modelo autoregresivo es más preciso que la caminata aleatoria en la mayoría de los precios de materias primas no energéticas en un horizonte mensual.

La principal contribución de este capítulo a la literatura tiene que ver con el aporte de evidencia empírica del grado de comunalidad que es útil para fines de predicción. Se demuestra que la evolución conjunta de los precios de las materias primas con características similares (como el existente dentro de cada categoría) tiene poder de predicción sobre los precios de las materias primas no energéticas. Por el contrario, el contenido predictivo del movimiento conjunto existente en largas cantidades de materias primas resulta muy bajo. La contribución es importante no sólo porque se reporta el éxito relativo del uso de modelos factoriales en la predicción de la inflación de las materias primas no energética en horizontes cortos, sino también porque se ha añadido al debate académico el tema de la capacidad de pronóstico en los cambios de los precios de las materias primas

Capítulo 4. Relaciones de largo plazo entre los precios de las materias primas, el tipo de cambio real y la desindustrialización relativa en una economía dependiente de materias primas. Evidencia empírica de "Enfermedad Holandesa" en Colombia.

Este capítulo refleja un cambio en la dirección del análisis de la evolución de los precios de las materias primas en comparación con los estudios previos, los cuales evalúan principalmente la sincronización de los precios de las materias primas no energéticas, los factores que los afectan y la capacidad predictiva de dicho movimiento conjunto . El capítulo, por el contrario, se mueve hacia el análisis del impacto de los precios de los productos básicos en las variables macroeconómicas de una economía pequeña y dependiente de estos, como la de Colombia. Acorde a lo comentado al inicio de la introducción, las fluctuaciones en los precios de las materias primas son cruciales en varios aspectos de la economía. Por lo tanto, una perspectiva global de la evolución de los precios de las materias primas debería tener en cuenta no sólo los factores que determinan los precios de las materias primas a nivel internacional, sino también el impacto que éstos pueden tener en una economía exportadora de materias primas. De esta manera, el artículo se introduce en la literatura que evalúa los posibles efectos negativos de los periodos de auge en los precios de las materias primas sobre las economías exportadoras de estos bienes. En particular, el artículo se centra en evaluar posibles síntomas del fenómeno conocido como la Enfermedad Holandesa en Colombia.

El término Enfermedad Holandesa data del año 1970 y hace referencia a los efectos nocivos que trajo consigo el descubrimiento de grandes depósitos de gas en el Mar del Norte sobre el sector industrial en Holanda. El repentino incremento en la riqueza de un país exportador de materias primas puede crear una entrada de capitales sin precedentes generando la apreciación real de la moneda holandesa y, por lo tanto, la pérdida de competitividad a nivel internacional de los productos industriales exportados por el país. La dependencia de Colombia en las exportaciones de materias primas y el posible efecto sobre la desindustrialización del país causado por la apreciación del tipo de cambio motiva esta investigación.

Colombia es un caso especial dentro de las economías dependientes de materias primas dado que en el tiempo sus exportaciones han estado concentradas en materias primas diferentes, café primero y más recientemente el petróleo. Por lo tanto, metodológicamente el estudio se realiza mediante análisis de largo plazo y evalúa a través de un Modelo de Corrección de Error (VECM, por sus siglas en inglés) si los precios de los productos básicos están relacionados con el tipo de cambio real y la producción manufacturera relativa. También se tienen en cuenta variables como la productividad, el gasto del gobierno, el grado de apertura comercial y la inversión extranjera para el período comprendido entre 1972 y 2012.

Las estimaciones muestran que los precios de las materias primas se relacionan positivamente con la tasa de cambio real en el largo plazo, sin embargo la producción manufacturera relativa no se ve afectada por apreciaciones reales de la moneda local. Por lo tanto, los aumentos en los precios de las materias primas tienen un efecto negativo en la competitividad del país sin causar desindustrialización relativa. Los resultados también muestran que el gasto público es una fuente importante de presión sobre el tipo de cambio real en Colombia.

La contribución más importante de este artículo se encuentra en el análisis del fenómeno de la Enfermedad Holandesa en un contexto de largo plazo. El auge en los precios de las materias primas en los países productores crea no sólo posibles desventajas, como la pérdida de competitividad y un mayor nivel de especialización en la producción del recurso exportado y en los sectores no comercializables, sino también ventajas como el aumento de la riqueza del país, mayores ingresos fiscales para inversión social y una mejora en la balanza de pagos. Por lo tanto, los efectos netos derivados de períodos de expansión en las materias primas exportadas por un país no se pueden observar en un contexto de corto plazo. Hasta ahora, los estudios se han centrado especialmente en el último auge del café (por ejemplo Puyana, 2000, Meisel 1998, Edwards, 1984 y Kamas, 1986) sin cubrir los dos episodios históricos de auge en el sector de las materias primas exportadas: el aumento de los precios del café (1975 - 1977) y el aumento en los precios del petróleo (2003-2008). Por lo tanto, dado que el capítulo tiene en cuenta una perspectiva de largo plazo, ofrece la capacidad de evaluar si los efectos adversos asociados a la enfermedad holandesa compensan los efectos beneficiosos de la expansión.

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Chapter 1

Introduction

1.1. Overview

This thesis relates to raw material prices, and concentrates on issues such as the global factors that drive the developments in a large set of non-energy commodity prices; the impact of market uncertainty in determining common evolution among commodity prices; the predictive power of co-movement in raw material prices; and the possible channels whereby the evolution of raw material prices impacts the economy of a commodity-dependent country such as Colombia. These topics are presented in three chapters, which can be read as independent essays.

The evolution of commodity prices is a very important issue since it can affect in one way or another the economy of a country. Many of the things which are eaten and used everyday are related to raw materials, from the gasoline that powers the ships and trucks that transport products, to the copper in electrical wiring and the food on our plates. Fluctuations in commodity prices are especially relevant to commodity-dependent economies, not only because raw materials account for a large share of total exports, which can lead to a greater vulnerability of these countries in terms of trade shocks, but also from a fiscal standpoint, because a great amount of fiscal income often comes from this sector. Hence, commodity price booms and busts can result in procyclical government spending if the country is not sufficiently diversified in matters of taxation, or lacks tax regulations. In the case of commodity importers, swings of raw material prices are directly related with inflation, which may make monetary policy more difficult to manage during periods of boom and bust in commodity prices. Finally, for many low development countries that import commodities, the increase in the prices of these goods can lead to higher levels of poverty, since a larger share of their income is used to buy food.

In view of the importance of commodity prices for most of the countries around the world, it is relevant to know which forces are behind the international movement of raw material prices, how to improve forecasting power in commodity prices, and how the evolution of raw material prices can affect commodity-dependent economies such as Colombia.

This introduction continues with a brief summary of the essays presented for this thesis, with particular attention to the motivation and contribution of each one. The remainder of the thesis is organized as follows: chapter 2-4 contains the essays of the thesis. The conclusion in Chapter 5 is then divided into three parts: an overall conclusion, which rounds off the conclusions of the thesis as a whole; future developments, which assess further research topics derived from the thesis; and dissemination of results, which lists the congresses and seminars where the essays have been presented, as well as the state of publications and the awards that have received.

1.2. Essays of the Thesis

This chapter section offers an outline of the forthcoming individual chapters of the thesis: in particular, it offers an in-depth summary of the research objectives and the major findings and contributions.

Chapter 2. Common dynamics of non-energy commodity prices and its relation to uncertainty.

The purpose of this essay is to improve the empirical evidence on commodity prices in various dimensions. First, we attempt to identify the extent of synchronized movements in 44 monthly non-energy commodity price series. The aim is to ascertain whether the links among commodity prices, or co-movement, have increased since the end of 2003, as result of the large increase of assets allocated to commodity indices by speculative financial traders, or so called financialization of commodity markets. Our hypothesis relies on the idea that the financialization process may transform price determination in the commodity market in the short term. Hence, commodity prices as a whole perform more like a speculative price, such as stock prices and currencies. Accordingly, without disregarding the importance of classical macroeconomic factors, financialization in the commodity markets may lead to a growing relevance of speculative variables in non-energy price determination.

Second, we attempt to evaluate the relative importance of macroeconomic fundamentals as well as financial variables in determining co-movement between non-energy prices in the short term. Importantly, we determine the role of market uncertainty as a potential driver of overall price movements. We use monthly data from February 1992-December 2012 and break the sample down into, say, pre-2004 and post-2004 periods, in order to evaluate whether the relative importance of financial variables such as the stock market and market uncertainty changed in the financialization period.

With regard to the methodology, we diagnose the overall co-movement using a Dynamic Factor Model estimated by principal components. In order to assess the relationship of fundamentals, financial and uncertainty variables with the co-movement in commodity prices, we use a Factor-Augmented Vector Autoregressive (FAVAR) approach, proposed by Bernanke, Boivin and Eliasz (2005). From the FAVAR model we present the impulse response functions, since they can trace the effects over time on a variable of an exogenous shock from another variable; and the variance decomposition of the non-energy factor, as it shows the relative relevance of each of the variables in determining the non-energy price co-movement.

The conclusions drawn in this first essay are summarized as follows: first and foremost, we found a greater synchronization among raw materials since December 2003, as suggested in the financialization hypothesis. More precisely, the variance of commodity prices explained by the common behavior of these prices, increased from 9% between February 1992 and November 2003, to 23% between December 2003 and December 2012. This means that after 2004 the common behavior of commodity prices accounts for a larger share of fluctuations than in the pre-financialization period, namely pre-2004. Secondly, impulse response estimates in the FAVAR model indicate that shocks in the stock market index as well as in the market uncertainty variable significantly affect non-fuel commodity prices only after late 2003. A stock market shock is followed by increases in price co-movement, which show the strengthening of cross market linkage for the second sub-period. In relation to the effects of uncertainty, we find that an increase in this variable leads to a decrease in non-energy commodity prices, which means that uncertainty makes commodity investors more risk averse and willing to sell. Thirdly, the variance decomposition analysis in the FAVAR model shows that the uncertainty element plays a larger role in explaining non-energy fluctuation for the second sub-period. In particular, the percentage of variance of the forecasting error of the non-energy factor, at a 12 month horizon, which is attributable to a shock in uncertainty, increased from less than 5% in the first sub-period, to 17.4% in the second subperiod. In fact, after late 2003, uncertainty shocks account for a larger share of variance decomposition of non-energy commodity prices than fundamentals, such as real exchange rate and world demand, which emphasizes the growing importance of uncertainty as an important determinant of communalities in non-energy commodities.

The most important contribution of this essay to the literature has to do with the understanding of the role of uncertainty, as well as speculative variables, such as the stock market prices in the non-energy price determination within a short term context. Few studies exist that analyze this topic in general, and none in a short and speculative context. This study aims to fill this void. Moreover, by considering a sample breakdown taking into consideration the starting date of the financialization period, we check whether co-movement has recently been more affected by speculative variables. Other contributions of the thesis to the literature of co-movement in non-energy commodity prices are: the use of higher frequency data in the FAVAR model; and the use of a previously unused variable in the study of uncertainty in commodity prices: the Chicago Board Options Exchange Volatility Index (VIX), which takes into account the expected volatility in the future market. We prove the robustness of our results against other measures of uncertainty such as the Economic Policy Uncertainty Measure and the Equity Uncertainty Measure constructed by Baker, Bloom and Davis (2013), neither of which have ever been used in this type of study.

Chapter 3. The predictive content of co-movement in non-energy commodity price changes.

This essay is a result of the findings in the previous chapter "Common dynamics of non-energy commodity prices and its relation to uncertainty" and of the idea that commodity prices may recently behave more as speculative prices. In the first essay we found that the co-movement among different non-energy prices largely increased after late 2003 when compared with the previous period. Additionally, for the second sub-period, there is a great fraction of movement in commodity prices that does not seem to be attributable to fundamentals. The aim of this essay, therefore, is to explore whether co-movement in prices of non-energy commodities has any predictive content over spot price changes.

Moreover, we aim to assess which degree of communalities or co-movement performs better for forecasting purposes: a large scale co-movement, which comprises the common evolution of a wide range of non-energy commodity prices, or a small-scale co-movement, which contains the common pattern of commodity prices within the same category. It is also of interest to explore whether the predictability of commodity prices varies across different types of categories.

We use the International Monetary Fund commodities database, which comprises 44 monthly commodity price series split in the categories: cereals, meat and seafood, beverages, vegetable oil and protein meals, agricultural raw materials and metals. Methodologically, we use a Dynamic Factor Model (DFM) framework to extract a latent factor that drives the co-movement on non-energy commodity price inflation. We use two estimation methods within the DFM approach: principal component, to extract the common evolution of the whole commodity price data set, which we call the large-scale factor model; and the Kalman filter to extract factors within categories, which we call the small-scale factor model. The basic idea is to take the extracted factor, estimated either by principal components, or by Kalman filter, and used it to forecast commodity inflation. We also estimated a univariate autoregressive (AR) model, and a random walk model, used as a benchmark. Our measure of forecasting performance is the out-of-sample root mean square error of prediction (RMSE) for one-step-ahead forecasts. The sample began in January 2004 and finished in December 2013; the forecasting evaluation period corresponds to 2011:01– 2013:12, changing the estimation sample as needed to generate true ex-ante one step ahead forecasts.

The main conclusions of this essay may be summarized as follows. Overall, we obtained promising results with the small-scale factor model. Specifically, predictability is strongest for metals, vegetable oils and protein meals, where RMSE by far outperforms both the AR and the random walk specification. In contrast, the large-scale factor model do not show improvements, compared to the small-scale factor and the AR model, which implies that they cannot be exploited for forecasting purposes.

The main contribution of this essay is to provide an empirical assessment of the degree of communalities that could be useful for forecasting purposes. This essay demonstrates that the common evolution of commodity prices with similar characteristics has forecasting power over non-energy commodity price changes. In contrast, the predictive content of large-scale DFM´s forecasts on the price inflation of non-energy commodities proved disappointing. The contribution is important not only because relative success in using factor models in forecasting the nominal price of non-energy commodity changes at short horizons is reported, but also because we contributed to the academic debate about the forecastability on commodity price changes.

Chapter 4. Long-term links between raw material prices, real exchange rate and relative de-industrialization in a commodity-dependent economy. Empirical evidence of "Dutch Disease" in Colombia.

This essay reflects a change in the direction of previous studies, which evaluate the synchronization of non-energy commodity prices, factors that impact them and the capacity of co-movement to forecast. In this essay I move toward the impact of commodity prices on macroeconomic variables in a small commodity-dependent economy such as Colombia will be. As I previously commented, for commodity-dependent economies the evolution of these prices is crucial in several aspects of the economy. Hence, a global perspective of the evolution of commodity prices has to take into account not only that which drives commodity prices at international level, but also what the impact of these price improvements is in a commodity-exporting economy such as Colombia. In this way, this essay deals with the literature that evaluates possible negative effects of commodity booms on commodity-dependent economies. In particular, the essay centers on evaluating possible symptoms of the phenomenon known as *Dutch Disease* in the long run.

The term *Dutch Disease* appears in relation to the discovery in the Netherlands of large gas deposits in the North Sea and its harmful effects on the country´s industrial sector. The sudden increase in the country's wealth created an inflow of capital never previously seen, which led to an appreciation of its currency and, therefore, a loss of competiveness in the non-energy exporting sector. Colombian commodity export dependence, and its possible effect on the de-industrialization of the country due to the appreciation of the exchange rate, motivates this research.

Colombia is a special case among commodity-dependent economies since it has been dependent on two different commodities, coffee first, and more recently oil. Hence, methodologically the study focuses on long-term analysis and testing by means of a Vector Error Correction Model about the relation among commodity prices and the real exchange rate and the relative manufacturing output. We also take into account variables such as productivity, government expenditure, the degree of trade openness and international inflows for the period between 1972 and 2012.

Estimations show that commodity prices are positively related to the real exchange rate in the long term; however, relative manufacturing output is not negatively affected by the real exchange rate. Thus, increases in commodity prices have a negative effect on the competitiveness of the country without causing relative de-industrialization as yet. Our result also shows that public spending is a major source of pressure on the Colombian real exchange rate.

The most important contribution of this essay has to do with the analysis of the Dutch Disease phenomenon in a long term context. Commodity booms in producing countries create not only possible disadvantages such as the loss of competitiveness and higher levels of specialization in the production of the resource and in non-tradable sectors, but also advantages such as an increase in the country's wealth, greater fiscal income for social investment and an improvement in the balance of payments. Therefore, net effects may not be observed within a short term context. Until now, studies have centered specially on the last coffee boom (e.g. Puyana, 2000, Meisel 1998, Edwards, 1984 and Kamas, 1986) without covering the two historical episodes of boom in the commodity exporting sector: the increase in coffee prices (1975-1977) and the increase in oil prices (2003-2008). Thus, since this essay takes into account a long term perspective, it is able to evaluate whether the adverse effects associated to *Dutch disease* offset the beneficial effects of commodity upsurge.

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Chapter 2

Common dynamics of non-energy commodity prices and its relation to uncertainty.

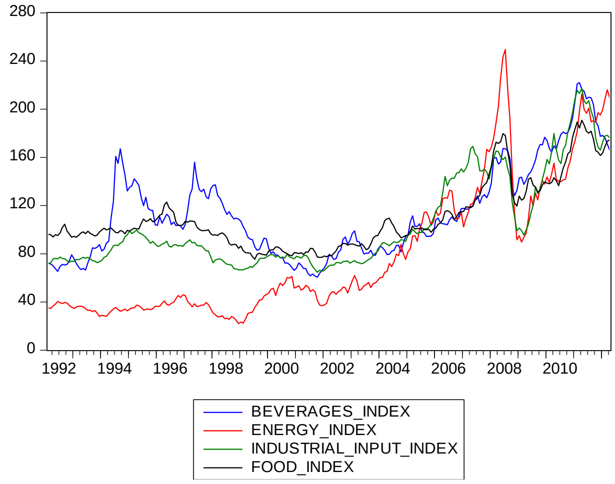
2.1. Introduction

One interesting characteristic of raw material prices is their tendency to co-move in response to the same shock. Thus, prices which should apparently not be correlated have a common evolution in time. For Pindyck and Rotemberg (1990), there are macroeconomic variables such as the industrial production of developed countries, interest rates and the exchange rate, which influence a large group of raw materials, since they affect the current market as well as the short-term expectation of demand and future supply. Pindyck and Rotemberg (1990) found that commodity prices co-move in "excess" of what can be explained by these variables. This evidence casts a shadow of doubt over the competitive formation of prices in the commodity market, and offers the possibility of studying the role of speculation in this market.

Recently, and in view of the significant increase in raw material prices in the period between 2002 and 2008 (see Figure 2.1), researchers have once again taken up the debate on the importance of the basic macroeconomic variables which may affect co-movement with regard to the role of speculation by index investors or so-called financialization of commodity markets (see, e.g., Tang and Xiong, 2012, and Irwin, Sanders and Merrin, 2009). An intense debate among scholars started with a Hedge Fund manager´s testimony, that of Mr Michael W. Masters, at the U.S Senate. Masters (2008) drew attention to the fact that the increase in speculative activity in commodity markets, due to the arrivals of new financial traders like Corporate and Government Pension Funds, modified the price determination in the commodity market. According to Masters (2008), assets allocated to commodity indices by institutional investors had risen from 13 billion at the end of 2003 to 260 billion as of March 2008, driving commodity prices higher.

The aim of this paper is to improve the empirical evidence on commodity prices co-movement in several dimensions. First, we attempt to identify the extent of co-movements in a larger set of commodities, in particular, we analyze 44 monthly non-fuel commodity price series. The aim is to ascertain whether the links among commodity prices, or co-movement, have increased since the end of 2003, as suggested by the promoters of the financialization hypothesis (Tang and Xiong, 2012 and Masters, 2008, among others). Second, we attempt to determine the role of uncertainty as a potential driver of non-energy co-movement in the short run. The extent to which this co-movement is driven by macroeconomic fundamentals and financial variables is also examined, in order to analyze their relative importance. While we evaluate the effect of uncertainty on commodity co-movement, we add to the recent business cycle literature on the macroeconomic effects of "uncertainty" shocks, Bloom (2009), Bernanke (2012) and Baker, Bloom and Davis (2013). Finally, as suggested by Frankel and Rose (2010), there is a lack of empirical evidence with higher frequency data, since most analyses are performed using annual data. The use of monthly data allows us to focus on fluctuations due not only to fundamentals but also to speculative or financial causes.

Figure 2.1: Indices of Market Prices for Non-fuel (Beverage Food and Industrial Inputs) and Fuel (Energy) Commodities (2005=100, in terms of U.S. dollars).



Source: International Monetary Fund, IMF.

We use monthly non fuel commodity price data from January 1992 until December 2012 and proceed in two steps: First, the use of a large number of commodities and data from different sectors allows us to use a dynamic factor model approach, and to estimate it through principal components. We diagnosed the overall co-movement and confirmed the presence of one latent factor driving commodity prices with the information criteria suggested by Bai and Ng (2002). While we were evaluating the importance of this common factor for the variance of non-fuel commodity prices before and after the end of 2003, we found a very interesting fact: the variance of commodity prices explained by the common factor jumped from 9% in the first sub-period, February 1992- November 2003, to 23% in the second sub-period, December 2003-December 2012. In terms of the scope of the analysis, we present a `before and after´ perspective by looking at two periods; before and after December 2003. Second, we use a Factor-Augmented Vector Autoregressive (FAVAR) approach, proposed by Bernanke, Boivin and Eliasz (2005), to study if the co-movement of commodity prices is affected in the same way by macroeconomic and speculative variables, as well as the uncertainty variable in the two sub-periods.

Our study provides an understanding of the role of uncertainty and fundamental variables that drive co-movement in commodity prices in these two periods. Therefore, our contributions to the literature on co-movement in commodity prices are twofold. First, by considering two different periods, we check whether co-movement is affected in the same way by fundamental and speculative variables, irrespective of time. It is our aim to ascertain which variables; fundamental, financial, or uncertainty, have a greater influence on the common behavior of non-fuel commodity prices.

Second, we examine the importance of market uncertainty in the co-movement of a range of non-fuel commodity prices in the short run. The closest paper to ours is Byrne, Fazio and Fiess (2013), although the two approaches differ in several aspects. First, we focus on the short-term relationship between co-movement in non-fuel commodity prices and macroeconomic and financial variables on a monthly instead of annual basis. The use of higher frequency data allows us to concentrate on speculative price-movements. We believe that the effects of uncertainty over commodity prices are better analyzed in a short-term context. Second, we apply a previously unused variable in the study of uncertainty in commodity prices: The Chicago Board Options Exchange Volatility Index (VIX). This variable reflects a market estimate of future volatility based on the weighted average of the implied volatilities for a wide range of options. Since uncertainty is forward looking, the variable VIX should be a better measure of uncertainty given that it takes into account the expected volatility in the future market. Third, we break the sample down in order to analyze the differences along the co-movement before and after the end of 2003 more efficiently. We believe that the sharp increase in the co-movement after that date deserves different treatment in the FAVAR model. Fourth, the estimation properties regarding consistency of the factor co-movement are better accomplished as we do not concentrate on a few commodities, as Byrne et al. (2013) do, but try to include as many as possible. Finally, we add two more variables to the FAVAR, a stock market index variable and the real U.S exchange rate, as they affect co-movement in the short term according to the literature (e.g. Vansteenkiste, 2009, Coleman, 2012).

The rest of the paper is organized as follows. In the next sub section, we briefly review the relevant literature. Section 2 reviews the methodology used in the study. Section 3 shows the main results and robustness checks. The conclusions are presented in section 4.

2.2. Related literature

We build mainly on the strand of literature that studies co-movements of commodity prices. However, our work is indirectly related to the growing literature on uncertainty and its effects on the economy.

The literature of co-movements in commodity prices is vast and begins with the seminal work of Pindyck and Rotemberg (1990) who state the excess of co-movement hypothesis. The idea put forward by Pindyck and Rotemberg (1990) suggests that prices of a wide range of commodities, at first sight uncorrelated and with cross elasticity of the demand close to zero, follow a common evolution over time. This conclusion is accepted by the authors, after taking into account a series of macroeconomic variables which may affect the set of commodity prices. For Pindyck and Rotemberg (1990), the common behavior of raw material prices should only occur as a reaction to common macroeconomic shocks. They found that the prices of commodities co-move in excess of what can be explained by macroeconomic fundamentals. The evidence of this "excess" of co-movement between different raw material prices implies not only that the price formation is not fully competitive, but also that speculation in commodity markets may play an important role.

In their rejection of the excess of co-movement hypothesis, some authors suggest that macroeconomic variables largely affect the development of raw material prices, e.g Dornbusch (1985), Chu and Morisson (1984), Borenzstein and Reinhart (1994) and Vansteenkiste (2009). Macroeconomic variables in empirical work include those related to demand, such as the production of developed countries, see Borenzstein and Reinhart (1994); variables related to the cost of supplies such as gasoline and fertilizer prices, see Baffes (2007); and variables such as the international situation, which can affect future expectations, and future returns, such as the effective exchange rate, and the US real interest rate, see Calvo (2008)[1]. The relative importance of each one of these determinants, as well as the factor attributed to speculation and uncertainty on the evolution of commodity prices, is currently the subject of debate.

[1] The link to the state of the business cycle is explored in Camacho and Pérez-Quirós (2013) in a different context using Markov switching models.

Financialization of commodity markets is cited as one of the sources of speculation, as well as being one of the main reasons behind the surge of raw material prices after 2003. This process has been described as the substantial increase in the investment in commodities as a form of asset. Tang and Xiong (2012) describe how the low correlation between commodity and market indices could lead to the investors' belief that raw material future investments could reduce portfolio risk. Therefore, after the collapse of the dot-com bubble around 2000 and 2001, various instruments based on commodity indices attracted investment. According to these authors, the financialization of commodity markets not only pushed prices up after 2003, but also permitted a greater correlation among different commodities. For Natanelov, Mackenzie and Huylendbroeck (2011) and Irwin et al. (2009) the proliferation of a variety of instruments such as exchange-traded funds (ETFs) and structured notes (ETNs), which bring together a number of commodities, also influence the co-movement of prices[2]. While one strand of academic research investigations focused on whether financialization is the cause of the upsurge in commodity prices, other authors have concentrated on the correlation between different commodities or between commodities and other financial indicators such as equities. Surveys by Irwin and Sanders (2011) and Fattouh, Kilian and Mahadeva (2013) cast doubts on the idea that the increased speculation in oil future markets in the post-financialization period was a key factor of the upsurge of oil prices. On the other side, Büyüksahin and Robe (2012) and Henderson, Pearson and Wang (2012) present evidence in favor of increasing correlation between equity indexes and commodities due to the presence of hedge funds. In the same line, Hamilton and Wu (2013) document that the risk premium in crude oil futures on average decreased and became more volatile since 2005. Since we

[2] In their article, Tang and Xiong (2012) use the end of 2003 and beginning of 2004 as the starting date of the financialization of the commodities.

divide our sample in December 2003, when index investment started to flow into commodity markets, we seek to add to the literature on the financialization of commodity markets by identifying the impact of energy and stock markets in determining the short run evolution on non-energy price co-movements[3].

Recently, the growing empirical literature on uncertainty has focused on its potential effects on the business cycle (e.g. Bloom 2009, Bernanke 2012, and Baker et al. (2013). According to Bloom (2009), higher policy uncertainty generates a slowdown in the economy, since businesses tend to postpone investment when there is an uncertain environment. Thus, an uncertainty shock has real effects on output, employment and productivity growth. Uncertainty can also affect risk-premium, which consequently increases the financing cost for entrepreneurs and countries. It may also increase precautionary savings in households, so generating a reduction in aggregate demand.

Despite the apparent importance of uncertainty for the real economy, the literature about its effects on commodity prices is scarce. Beck (1993, 2001) took commodity price volatility in the future market as a measure of risk. He found evidence that expected price risks have a significant effect on price behavior only for storable commodities. For Dixit and Pindyck (1994), uncertainty lowers production because the benefit of waiting grows in line with opportunity costs. Uncertainty, therefore, generates an increase in prices. On the contrary, Byrne et al. (2013) empirically found the opposite relationship between risk and commodity prices in a low frequency scenario. This result is in the line with literature that relates uncertainty with equity prices in the short run, suggesting that prices fall precipitously on negative news, and hence induce higher risk premiums (Pástor and Veronesi, 2011, Bekaert, Engstrom and Xing, 2009).

[3] Total net assets of commodity exchange trade funds grew 10.000% between 2004 and 2010 according to the Investment Company Institute.

2.3. Methodology

2.3.1. The FAVAR model

In the first part of this section, we provide a summary of the factor-augmented vector autoregressive (FAVAR) model that we use in the empirical section. For additional details, see Bernanke et al. (2005).

Dynamic factor models suggest that the information from a large number of time series can be summarized by a relatively small number of common factors plus idiosyncratic noises. In this context, we extract a factor that represents co-movements in commodity prices. We would like to assess for the responses of this factor to common macroeconomic and speculative shocks. For this purpose, we propose a Factor Augmented VAR (FAVAR) approach along the lines of Bernanke et al. (2005). The model is summarized in the following two equations:

$$\begin{bmatrix} F_t \\ X_t \end{bmatrix} = \phi(L) \begin{bmatrix} F_{t-1} \\ X_{t-1} \end{bmatrix} + v_t \qquad (2.1)$$

$$Y_t = \Lambda F_t + u_t \qquad (2.2)$$

where $Y_t = (Y_{1t}, \ldots, Y_{Nt})'$ is the $N \times 1$ vector of observed variables (non-energy commodity inflations in our case); $\Lambda = \left(\Lambda_1^{'}, \ldots, \Lambda_N^{'}\right)$, $N \times k$, is the factor loading matrix; F_t is the $k \times 1$ vector of common factors; u_t is the $N \times 1$ vector of idiosyncratic noises; X_t is the $p \times 1$ vector of macroeconomic and financial variables; $\phi(L)$ is the $(p + k) \times (p + k)$ matrix of lag polynomials and $v_t \sim (0, \sum_v)$ is the $(p + k) \times 1$ vector of error terms in the FAVAR specification.

Note that in equation (2.1) the latent variable (F_t) summarizes the developments of non-energy commodity prices. Therefore, the factor, F_t, represents the common pattern of commodities. In this context, equation (2.1) represents the joint dynamics of (F_t, X_t) and we call it FAVAR.

We cannot directly estimate equation (2.1) because the factor (F_t) is unobservable; therefore, we need to construct the factor beforehand. In our case, the dynamic factor model given by equation (2.2) gives the non-energy commodity price inflations (labeled as Y_t) driven by a latent component, F_t, that is common to all series and an idiosyncratic autoregressive component, u_t. The matrix Λ represents the loading of the common factors onto series. Each element of the error or idiosyncratic term, u_t, contains the dynamics specific to each commodity price inflation, although it is assumed to be weakly correlated[4]. The factor may also follow an AR process.

With regard to the estimation, we consider the two-step method favored by Bernanke et al. (2005), in which the factor is extracted prior to estimation of the FAVAR. The use of a large number of commodities allows us to estimate equation (2.2) through Principal Components. With this we assume that the weighted averages of the idiosyncratic disturbances will converge to zero by the weak law of large numbers, so linear combinations of the observed series are consistent estimators of the common factors. Consistency of the static Principal Components estimator has been demonstrated by Stock and Watson (2002) when both, the number of series N, and the time dimension T converge to infinity. Due to this consistency result, we can treat F_t as observed for inference purposes.

[4] For a discussion of dynamic factor models, see for instance, Bai and Ng (2008) and Stock and Watson (2011).

2.3.2. Data definition

In this section we describe the data used in the factor model, related to commodity prices and the macroeconomic and financial variables used in the FAVAR model.

For the dynamic factor analysis we used 44 monthly non-fuel commodity price series from February 1992 to December 2012. Monthly series of commodity prices were obtained from the International Monetary Fund database (IMF IFS). We include in our study the raw materials available in the following categories: food, beverages, agricultural raw material and metals. A summary of the commodities used in this study is shown in Appendix A.

With regard to the estimation, commodity prices are log differentiated and standardized, prior to the factor extraction by principal components. We follow Stock and Watson (2011) in this respect.

With the FAVAR model we attempt to determine the extent to which this common factor is driven by macroeconomic fundamentals, or whether uncertainty plays a major role. For this purpose we select the most important macroeconomic variables used in the literature of co-movements, and combine them with our proxy for uncertainty. Here we add the role of uncertainty as a potential determinant of commonalities in commodity prices. Specifically, we use the Chicago Board Options Exchange Volatility Index (VIX) which reflects a market estimate of future volatility. To the best of the authors' knowledge, this variable has not been used before in the analysis of commodity prices. The rest of the variables are:

- The United States exchange rate. We use the U.S real effective exchange rate. We expect that the decline in the real effective exchange rate may have added momentum to the upward commodities price movement.
- United States real interest rate, proxied in our analysis by the U.S. 3-Month Certificate of Deposit. We expect that lower rates of return on bonds will increase the speculative demand for commodities and hence further raise their price.
- World demand, proxied in our analysis by the World Industrial Production.
- Stock Market index. We take for our analysis the MSCI world index, which includes a large collection of world stocks in the developed markets. We use this variable as a proxy of the financial market condition.
- Supply shocks are proxied in our study by the Energy Index of the IMF. For some authors such as Krugman (2008), the increase in oil prices may explain the contemporaneous increase in other commodities, such as food products, through two different channels. Firstly, higher energy prices cause upsurges in the production cost which impacts on the rest of commodities final price. Secondly, the increased biofuel demand may lead to a reduction in food supply devoted to final consumption. The last two channels are more associated to long-run effects, since raw material supply is highly inelastic. In the short run, if the financialization hypothesis prevails, we would expect that energy and non-energy prices move in the same direction, given the speculative trade on commodities. The energy index is composed of natural gas and coal, besides oil.

Appendix B presents further details regarding the variables we include in the model. Graphical representations of the variables are shown in Appendix C.

2.4. Empirical Results

In this section we focus first on the specification of the Dynamic Factor Model and the analysis of the factor and loadings estimated by Principal Components. The estimation of the unobserved factors is the first steps, since we estimate the FAVAR using the two-step approach of Bernanke et al. (2005). Afterwards, we move on to the estimation of the FAVAR for both periods and compare their results.

2.4.1. Dynamic factor model

We identify the factor structure using the information criteria proposed by Bai and Ng (2002). Bai and Ng (2002) solve the optimization problem that comes from minimizing the sum of squared residuals (divided by NT), defined by:

$$V(k) = (NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} (Y_{it} - \lambda_i^k F_t^k)^2, \qquad (2.3)$$

where the super index k in $\lambda_i^k F_t^k$ denotes that k factors are considered. To determine the true number of factors, r (with $r \leq kmax$), Bai and Ng (2002) formulate the following information criteria:

$$PC(k) = V\left(k, \widehat{F^k}\right) + kg(N,T) \qquad (2.4)$$

$$IC(k) = \ln\left(V\left(k, \widehat{F^k}\right)\right) + kg(N,T), \qquad (2.5)$$

where $V(k,\widehat{F^k})$ is the average residual variance when k factors are assumed and $g(N,T)$ is a penalty function. Bai and Ng (2002) suggested three penalty functions to be taken into account for principal component estimation:

$$g_1(N,T) = \frac{N+T}{NT}\ln\left(\frac{NT}{N+T}\right) \quad (2.6)$$

$$g_2(N,T) = \frac{N+T}{NT}\ln(c_{NT}^2) \quad (2.7)$$

$$g_3(N,T) = \frac{\ln(c_{NT}^2)}{c_{NT}^2} \quad (2.8)$$

where $c_{NT} = min\{\sqrt{N},\sqrt{T}\}$.

In our case, the three criteria suggest that there is at least one common factor in the data, as can be seen in Table 2.1. Accordingly, we estimate one common factor, which we name co-movement, for the entire sample and also for the 2 periods we want to analyze: Pre Dec-2003 and Post Dic-2003.

Table 2.1: Number of factors estimated using Bai and Ng(2002) Criteria

Sample	Dates	No. Obs	IC_1	IC_2	IC_3
Full	1992:2-2012:12	251	1	1	1

Notes: All estimates use N=44 series

Figure 2.2, plots the first estimated common factor, which we call co-movement in non-fuel commodity prices. According to this factor, commodity price booms and busts tend to be relatively short-lived and the factor is more volatile after the end of 2003. Importantly, the variance explained by the factor increases significantly between subsamples. When estimating the first principal component for the period between February 1992 and November 2003, the proportion of the variance of commodity prices explained by the factor is only 9%. However, when the same procedure is performed for the period between December 2003 and December 2012, the variance explained increases to 23%. This would suggest that after the end of 2003, non-fuel commodity prices have become more synchronized or that fluctuations are higher.

Figure 2.2: Common Factor for Non-Energy Commodity Prices.

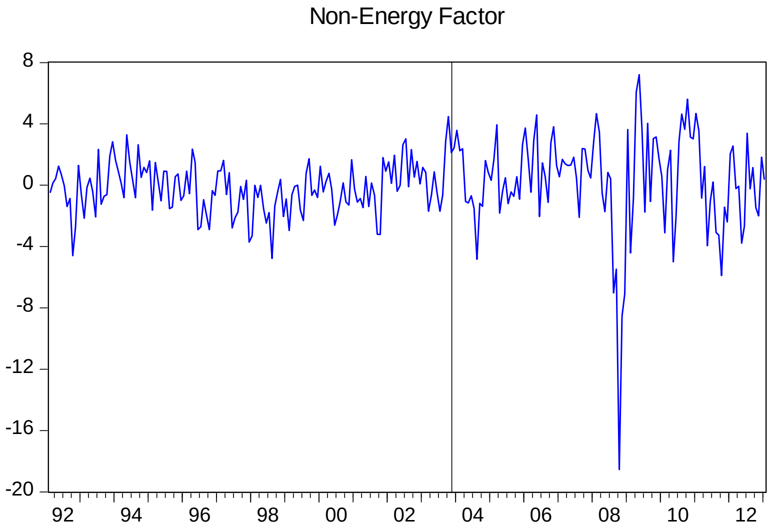


Table 2.2 shows the commodities with factor loadings above 0.10 in both periods. Although loadings in the first sub-period are larger for four commodities (greater than 0.30), fewer raw material prices reach 0.10 in their factor loading. For the second sub-period, in contrast, there are more commodities with loadings above 0.10. The correlation of the factor with each of the prices is greater in most of the commodities for the second sub-period. It is worth noting that some commodities greatly increased their relationship with the factor in the second period. Sugar, Rubber and Zinc for example, had a factor loading of only 0.123, 0.105 and 0.128, respectively, in the first period. After December 2003, however, their loadings went up to 0.21, for all three

commodities. The relationship between commodity prices and the factor increased for edibles in the IMF category of "Food" such as Fish and Beef, and in "Beverages" such as Tea and Coffee. In contrast, the factor loading decreases for "Raw Materials" related to the group Vegetable Oils and Protein Meal.

Table 2.2: Variance shares explained by the common factor and correlation for the two sub-periods. The table shows only commodities with a loading greater than 0.10.

	1992:2-2003:11	
	Loadings	Average correlation/ Global factor
Soybeans	0.393	0.803
Soybean oil	0.353	0.721
Maize	0.319	0.650
Soybean meal	0.311	0.634
Sunflower/Safflower Oil	0.300	0.612
Barley	0.288	0.588
Wheat	0.229	0.469
Nickel	0.221	0.451
Rapeseed oil	0.195	0.398
Tin	0.186	0.379
Copper	0.175	0.358
Cotton	0.168	0.343
Lead	0.168	0.343
Sugar	0.123	0.252
Zinc	0.128	0.261
Rubber	0.105	0.214

	2003:12-2012:12	
	Loadings	Average correlation/ Global factor
Soybean oil	0.266	0.803
Copper	0.238	0.720
Soybeans	0.231	0.698
Tin	0.225	0.678
Coarse	0.219	0.661
Wool Fine	0.217	0.654
Rubber	0.213	0.645
Sugar	0.211	0.639
Zinc	0.210	0.633
Rapeseed oil	0.209	0.631
Maize	0.207	0.625
Barley	0.207	0.624
Nickel	0.200	0.605
Lead	0.191	0.577
Soybean meal	0.183	0.553
Cotton	0.180	0.544
Wheat	0.168	0.509
Other Milds of Coffee	0.165	0.498
Coffee Robusta	0.158	0.478
Cocoa beans	0.135	0.409
Sawnwood	0.127	0.384
Fish	0.123	0.371
Olive Oil	0.121	0.364
Sugar Free Market	0.120	0.362
Groundnuts	0.117	0.353
Aluminium	0.110	0.332
Sugar US market	0.110	0.331
Uranium	0.103	0.312

Our analysis has highlighted, hitherto, that the increase in commodity communalities started before the financial crisis. In this sense, our work is consistent with the vision of

Tang and Xiong (2012), in which the financialization of commodities, starting at the end of 2003, has increased the synchronization among raw material prices.

2.4.2. The FAVAR model results

In this section, we present the estimation results of the FAVAR model for the two periods analyzed. Our purpose is to examine the short-run linkages among the variables considered in the study. In particular, we are interested in analyzing the impact of uncertainty and macroeconomic and speculative variable shocks on non-fuel commodity prices. We use impulse response functions, as they can trace over time the effects on a variable of an exogenous shock from another variable. Before starting with the results, some final specifications of the model are discussed briefly.

As suggested by Bernanke et al. (2005), we use all variable data in first differences in order to induce stationarity[5]. Moreover, all price series have been transformed into real prices by dividing them by the US Consumer Price Index. We use Generalized Impulse responses for the impulse response function as described by Pesaran and Shin (1998), whose approach does not depend on the VAR ordering.

Our main results in both sub-periods are shown in Figure 2.3 and 2.4 below. Each figure shows the impulse responses of the non-fuel commodity factor to a one-standard deviation shock in all of the macroeconomic and financial variables selected. The FAVAR models, within the first period (pre December 2003) and the second period (post December-2003), were estimated with five and nine lags, respectively, in order to

[5] The variable VIX is included in first differences; however, our results are robust to the inclusion of this variable in the levels.

account for residual autocorrelation. The properties of the residuals of the estimated models have been analyzed. For details see Appendix D [6].

Figure 2.3: Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Period 1992:2/2003:11

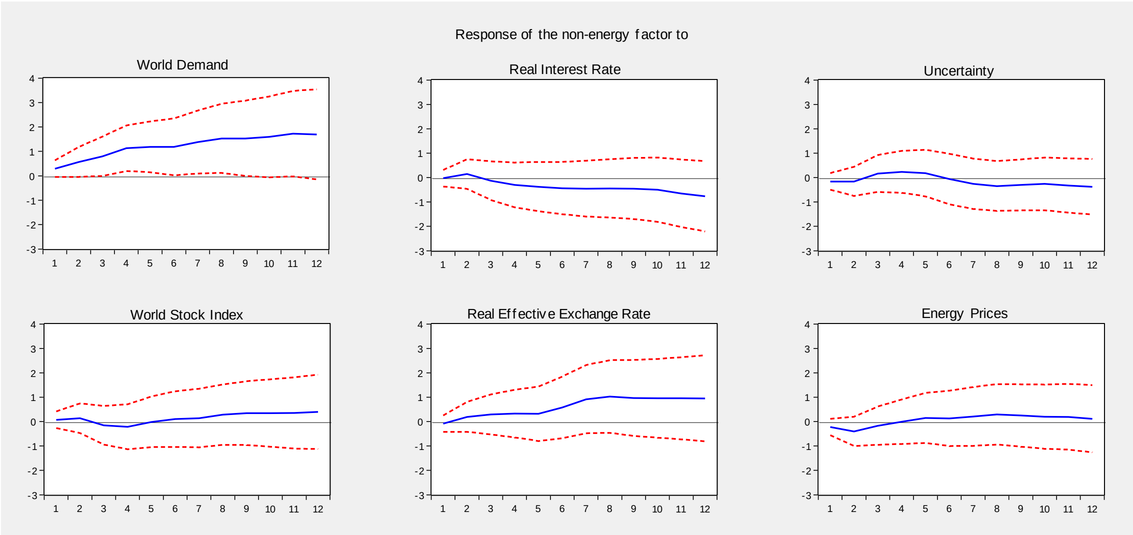
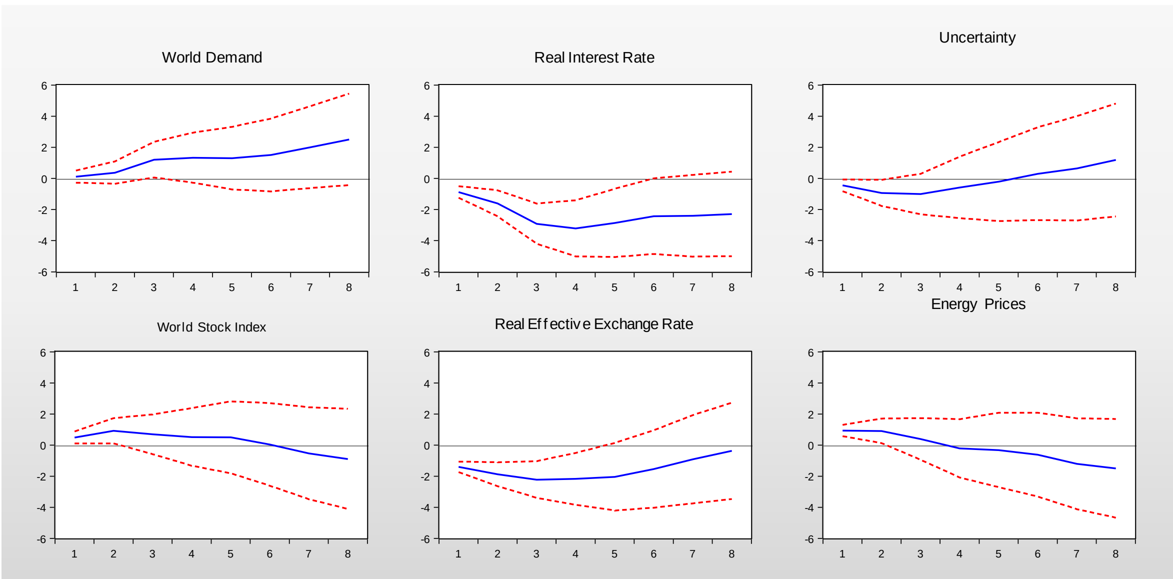


Figure 2.4: Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Period 2003:12/2012:12



[6] A dummy on December 2008 has been included in the FAVAR model for the second period to take into account the world economic crisis. We did not detect heteroscedasticity in the residuals of the FAVAR model.

For the period prior to December 2003, the impulse response functions of Figure 2.3 show that the co-movement in non-energy commodities is not significantly affected by most of the macroeconomic or speculative variables. Non-energy co-movement is only affected by a world demand shock. Instead, the shapes of the estimated impulse response functions for the second sub-period are in line with co-movement literature, see Figure 2.4. We obtain the following results for the second period:

Impulse response estimates from the FAVAR model indicated that a world demand shock seems to show a significant positive rise in non-energy commodity prices. Other macroeconomic variables, such as real interest rate and US real effective exchange rate, have a significant negative impact on non-fuel commodity prices. It seems that in the short run a positive shock in the US interest rate can make investors switch their portfolio investments from risky assets, such as commodity futures, to more conservative ones, such as US treasury bills. The negative effect of a shock on real interest rate on the non-energy factor lasts for 5 months, one of the more lasting effects regarding the impulse response results of the FAVAR model. On the other hand, a real appreciation of the US dollar makes commodity prices fall, as most of the raw material prices are internationally traded and quoted in U.S dollars. The negative effect takes four months to vanish. These results agree with the view that the increase in global demand, the real devaluation of the US dollar and the easy monetary policy of the United States may have added momentum to the upward price movement after 2003.

A supply shock, proxied in this study by energy prices, has an immediate effect on the non-fuel factor. However, this effect tends to disappear after the second month. In this context, we agree with the idea that there is a spillover effect from energy to non-energy commodity prices, enhanced perhaps by the financialization of commodity markets. This effect, however, is less lasting than the shocks in the fundamentals.

With regard to financial variables, we find significant responses of non-fuel commodity prices. Impulse response estimates indicate that a shock in the stock market index is followed by a two month rise in non-fuel commodity prices. These results show the strengthening of cross market linkage after the late 2003[7].

In relation with the effects of uncertainty, that it is proxied by VIX index in the study, we find that an increase in this variable leads to a decrease in the non-energy commodity prices for two months. It seems that uncertainty or volatility in the financial market makes investors more risk averse and bearing. This result is consistent with the ideas of Dixit and Pindyck (1994), in which uncertainty is associated with movements in commodity prices. The negative relationship between our uncertainty variable and commodity prices are in line with the results of Byrne et al. (2013) who tested it for the long run.

2.4.3. Robustness checks

We propose to check the robustness of our results against other measures of uncertainty, the number of factors within the FAVAR model, and the inclusion of inventories into the model.

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[7] Our findings are in line with the fast-growing literature on co-movements between commodity and equity markets over time –see, e.g., Silvennoinen and Thorp (2013), Stoll and Whaley (2010), Büyüksahin, Haigh and Robe (2010) and Büyüksahin and Robe (2012).

For other measures of uncertainty, we use both the "Economic Policy Uncertainty Measure" and the "Equity Uncertainty Measure" constructed by Baker et al. (2013). The former is constructed taking into account policy-related economic uncertainty with three types of components: frequency of newspaper coverage of policy-related economic uncertainty; federal tax code provisions which were about to expire; and disagreement among economic forecasters. For the second sub-period we took the United States as well as the European Monthly Index of Economic Policy Uncertainty of Baker et al. (2013). Since the European Monthly Index is constructed from January 1997, we only performed this measure for the second sub-period. The latter, the "Equity Uncertainty Measure" is based on an analysis of news articles in the United States containing terms related to market uncertainty. Robustness checks appear in Appendix E.

The results for the first sub-period show that all our non-energy commodity price reactions are not significant to any alternative uncertainty measure as is shown in our baseline model. The results for the second sub-period show that a shock in the European Economic Policy Uncertainty as well as in the Equity Uncertainty Measure has a negative impact on the non-energy commodity factor. The United States Policy Uncertainty, however, has no impact on our non-energy factor. From a quantitative standpoint, differences are found for the non-energy responses predicted by the VAR, embedding the European Policy Uncertainty indicator, which predicts much larger responses. However, all non-energy commodity responses are significant and take a sign in line with that suggested by the FAVAR with the VIX indicator.

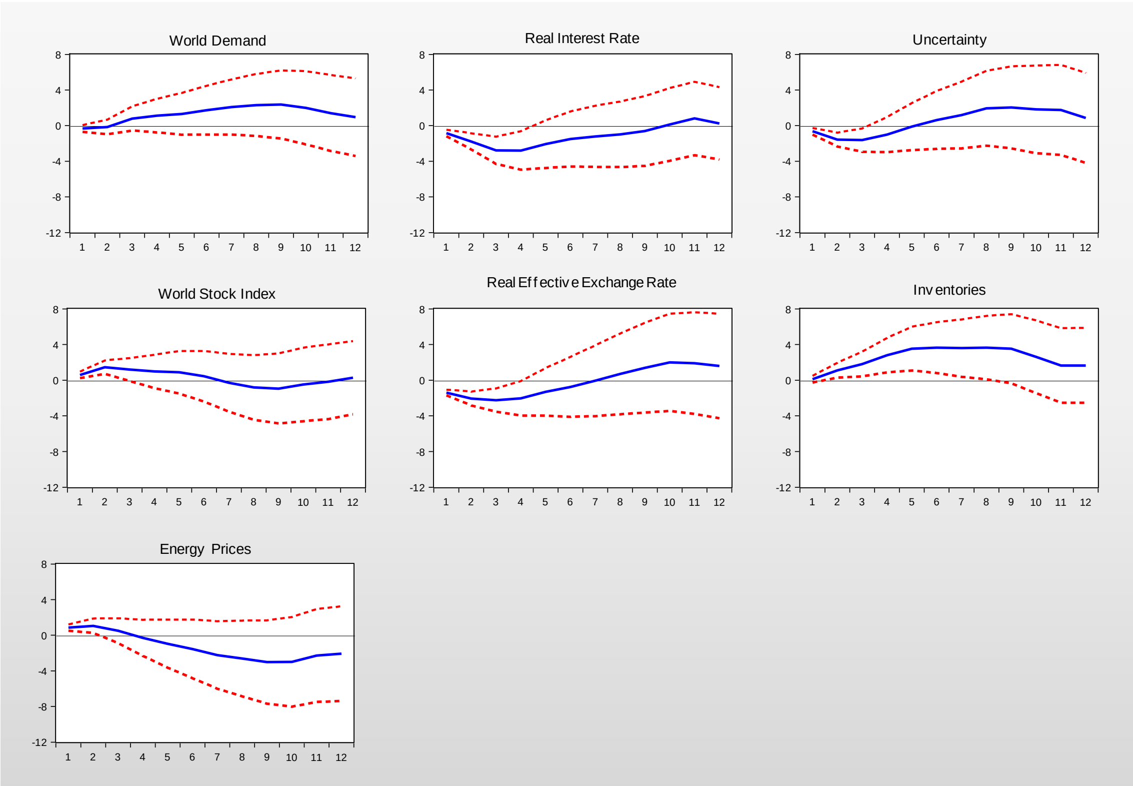
Although we found only one factor in the whole sample, the determination of the number of factors on the basis of subsamples, say pre-2003 and post-2003 periods, by the information criteria of Bai and Ng (2002) were not so clear, since the third IC pointed the possibility of 2 common factors. To tackle this issue, we evaluate whether our results are robust to two factors. We extract the second component, called a shape component, and re-estimate the FAVAR model, taking into account two factors for the second sub-period. The loadings of the shape component show a separation between metals commodities, with positive loadings, and edibles, with negative loadings. On the other hand, impulse response functions show the same results as our baseline model with regard to the responses of our first factor, called co-movement, to impulses on uncertainty and the rest of the variables. With regard to the shape component, we found significant responses to impulses of energy prices and the real effective exchange rate. Appendix F reports the robustness estimations of the FAVAR model with two factors for the second sub-period.

As a final robustness check we include an inventory variable in our FAVAR model[8]. For the second period we found two results: First, our results are robust to the inclusion of inventories. In fact, the FAVAR model with inventories implies a more important role for uncertainty shocks in explaining fluctuations in the co-movement of non-fuel commodity prices than previous estimates. As shown in Figure 2.5, an increase in uncertainty leads to a decrease in co-movement for three months. Second, inventories have a positive effect on non-fuel commodity prices. Either through fear of future production shortage or speculation (greater expected future prices), inventory accumulation leads to the reduction in the commodities available for current use, causing the non-fuel spot prices to rise.

[8] We used inventory data of only 12 non fuel commodities due to the lack of information available for the rest of the commodities at a monthly frequency. We use world inventories as far as possible, but substitute with US inventories when these are missing. We describe the inventory data used in Appendix B. The inventory variable is taken from estimating the first principal component of the 12 non-fuel inventories.

With respect to the first sub-period, we estimated the FAVAR with inventories of metals due to the lack of a longer data span for the rest of stocks of commodities. Results show little evidence that a positive shock on metal inventories affects the non-fuel commodity factor. This result contrasts with the positive relationship between inventories and non-fuel commodity prices for the second sub-period[9].

Figure 2.5: Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic, financial and inventory variables. Period 2003:12/2012:12



[9] We estimated the FAVAR model for both sub-periods, taking into account the inventories of metals. For the second sub-period we obtained similar results as the model with total inventories. Estimation results are available upon request.

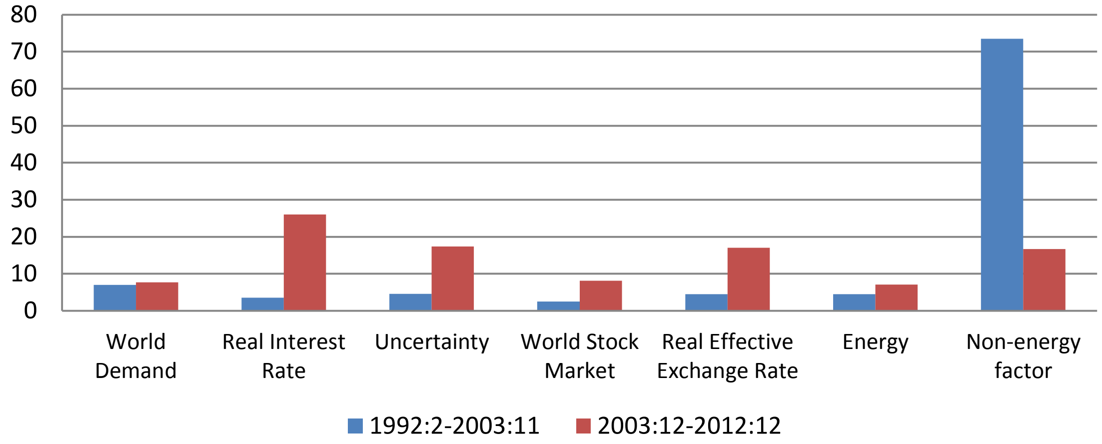
2.4.4. Variance decompositions

Now we present the variance decomposition of the non-energy factor for both sub-periods in order to assess the relative importance of each of the variables in determining the non-energy price co-movement. Yet, variance decomposition requires orthogonality of the inputs if we want the sum of variance due to each component to total 100%. We rely on a given Cholesky decomposition and, therefore, we propose the following ordering of the variables in the VAR: in both of the sub-periods we place our non-energy factor last based on the assumption that non-energy commodity market shocks have no contemporaneous effects on macroeconomic variables. World demand, proxied in our study by global industrial production, is placed first, followed by the interest rate, the volatility variable (VIX), the Stock Market index (MSCI), real effective exchange rate and the IMF energy index. This implies that demand shocks instantaneously affect all equations of the system, which seems logical if we consider that the real exchange rates and interest rates respond greatly to macroeconomic conditions[10].

Figure 2.6 illustrates the percentage of variance of the forecasting error of the non-energy factor, at a 12 month horizon, that is attributable to a shock in each of the macroeconomic and financial variables of the model.

[10] As a robustness check for this part, we evaluated a different Cholesky ordering of the variables in the VAR with similar results.

Figure 2.6: Variance decomposition of the non-energy factor



Note: Variance decomposition at horizon 12.

In the first sub-period the non-energy factor is the most important driver of its own prices, accounting for more than 70% of price fluctuation. Therefore, inertia has a dominant role in explaining the factor fluctuations. Considering the other variables rather than the lags themselves of the common factor, world demand shocks are the most important driver, explaining up to 7% of non-energy price changes. The rest of the variables shocks account for less than 5% of the non-energy factor.

In the second sub-period the relative importance of the shocks is greatly altered. Real interest rate is now the most important driver of co-movements in non-energy commodity prices, accounting for up to 26% of price fluctuations. The role of a shock in uncertainty is notable, explaining 17.4% of the variation in non-energy prices at all horizons, the second most important driver of the non-energy factor for this period. Shocks in the fundamentals, such as real effective exchange rate and world demand, account for up to 17% and 8%, respectively. Finally, the stock market index variable and the energy variable explain 8% and 7%, respectively, of the variation in non-energy price fluctuations.

The most important result from this comparison is the increase in the role of uncertainty to explain non-energy fluctuations. The fact that the uncertainty shock accounts for a larger share of variance decomposition of non-energy commodity prices than fundamentals, such as real exchange rate and world demand, emphasizes its importance in determining non-energy spot price formation. Financialization of commodities may make investors much more aware of short term economic developments and may cause passive investors to take collective decisions such as selling risky assets, like commodities, when uncertainty increases, given their correlation with other risky assets.

In conclusion, in the short term, the speculative variables used in our study, which reflect the financial market condition (world stock index) and uncertainty (VIX), significantly affect the real prices of non-fuel commodities in the second period, after the end of 2003. The role of the uncertainty element in determining the joint movements of non-energy prices is noteworthy.

2.5. Conclusions

This article improves the understanding of the co-movement among non-fuel commodity prices in the short run adding to the literature on financialization of commodity markets. Firstly, we evaluate the magnitude in the co-movement of 44 monthly non-fuel commodity prices from February 1992 to December 2012. Secondly, we break our sample in December 2003, as it is the starting date of unprecedented upsurge of investment into commodity trade funds, in an attempt to ascertain whether co-movement is affected in the same way by fundamentals, financial and speculative variables. We evaluate the responses of non-energy commodities to macroeconomic and financial shocks for these two sub-periods. As we focus in the short run, special attention is paid on the role of the stock market index variable as well as uncertainty in the financial market as a possible determinant of commonalities in commodity prices. With regard to the methodology, we use the FAVAR approach of Bernanke et al. (2005) in order to check what drives co-movement in non-energy commodity prices.

Our results highlight the importance of co-movement between non-fuel commodities that started after the financialization of commodities in late 2003. In this period we found not only an increase in the variance explained by the factor attributable to the co-movement between raw materials, but also the impulse response functions show that variables such as uncertainty and the stock market index significantly impact the factor that relates co-movements in non-energy commodity prices. Moreover, the variance decomposition analysis shows that the uncertainty element plays a larger role in explaining non-energy fluctuation than fundamentals such as the real exchange rate and the real interest rate.

In short, although classical macroeconomic factors of supply and demand are able to explain much of the sharp movements in the short term in non-fuel commodity prices, the growing importance of uncertainty as an important determinant of communalities in non-energy commodities is an element that cannot be ignored.

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Appendix A: Non fuel commodities

IMF Category		Commodity	
Edibles	**Cereals**	Rice	Maiz
		Barley	Wheat
	Meet and seafood	Beef	Poultry (chicken)
		Lamb	Fish (salmon)
		Swine (pork)	Shrimp
	Beverages	Cocoa beans	Coffee, Robusta
		Coffee, Other Mild Arabicas,	Tea
	Vegetable oils and protein meals	Soybeans	Sunflower Oil
		Soybean Meal	Olive Oil
		Soybean Oil	Groundnuts (peanuts)
		Palm oil	Rapeseed oil, crude.
		Fishmeal	
	Other Edibles	Sugar EU.	Oranges
		Sugar US.	
		Bananas	
Industrial Inputs	**Agricultural raw materials**	Soft Logs	
		Hard Logs	Wool, fine
		Hard Sawnwood	Rubber
		Soft Sawnwood	Hides
		Cotton	Wool, coarse
	Metals	Aluminum	Zinc
		Copper	Nickel
		Iron Ore	Lead
		Tin	Uranium

Appendix B: Macroeconomic and Financial Variables

U.S Real Effective Exchange rate. Reer Based on Rel.cp /Index Number /averages /seas. adjusted /Cnt: United States /Source: IMF, Wash

U.S Real interest rate. 3-Month Certificate of Deposit: Secondary Market Rate/Unit: Percent /Cnt: United States /Source: FRED

Energy Index. The Commodity Fuel (energy) Index includes Crude oil (petroleum), Natural Gas, and Coal Price Indices. Base year: 2005/source: IMF.

World Industrial Production. Data from CPB Netherlands Bureau for Economic Policy Analysis

MSCI (Morgan Stanley Capital International) World Index. Data from Bloomberg

VIX index. The Chicago Board Options Exchange Volatility Index reflects a market estimate of future volatility, based on the weighted average of the implied volatilities for a wide range of strikes. 1st & 2nd month expirations are used until 8 days from expiration, then the 2nd and 3rd are used. Source: Bloomberg [BBGID BBG000JW9B77]

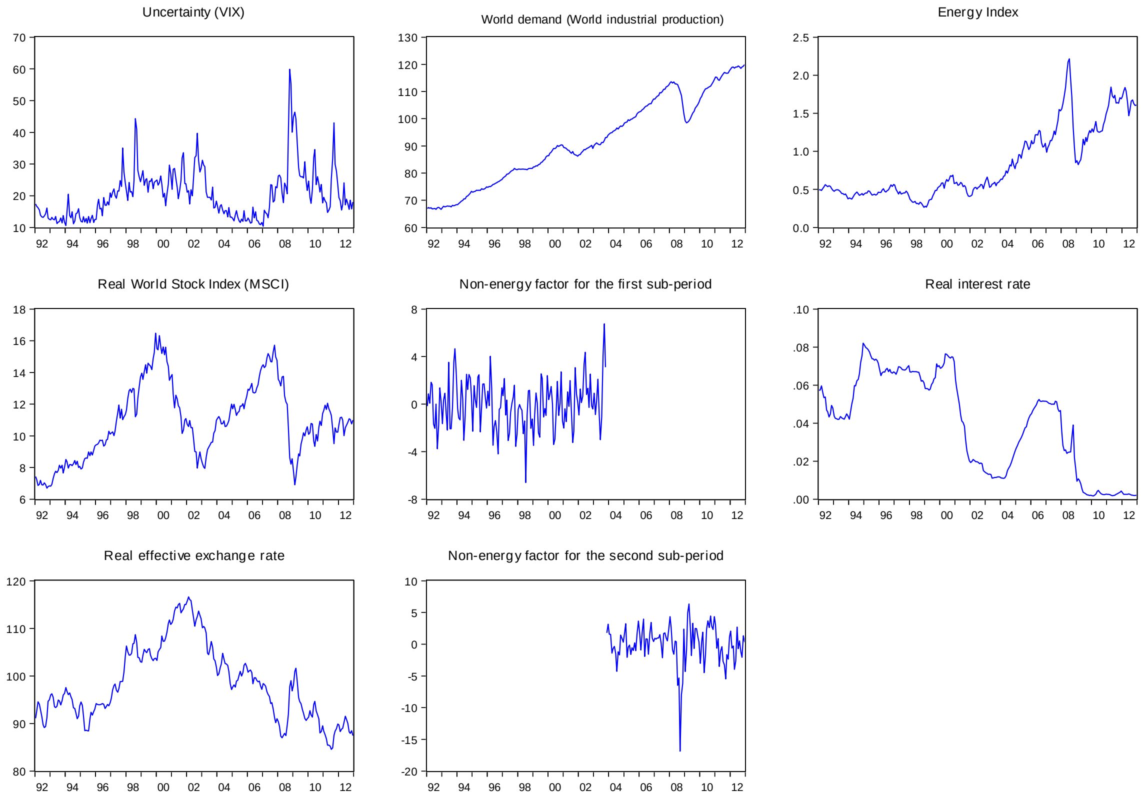
We used the Consumer Price Index to deflate the series that was not in real terms. Especifically: Cpi all Items City Average /Index Number /Base year: 2005 /averages /Cnt: United States /Source: IMF, Wash

Name and sources of the inventory data used in in the robustness check section

Name	Ubication	Frequency	Period	Source
Wheat Ending Stocks Million Bushels	United States	Monthly	1990:1-2012:12	United States Department of Agriculture, USDA.
Sugar Stocks to Use-Months	Global	Monthly	19977:1-2012:12	F.O. Licht
Aluminium Warehouse Stocks Metric Tonnes	Global	Monthly	1987:7-2012:12	London Metal Exchange
Copper Warehouse Stocks Metric Tonnes	Global	Monthly	1988:10-2012:12	London Metal Exchange
Tin Warehouse Stocks Metric Tonnes	Global	Monthly	1989:05-2012:12	London Metal Exchange
Zinc Warehouse Stocks Metric Tonnes	Global	Monthly	1988:09-2012:12	London Metal Exchange
Nickel	Global	Monthly	1987:7-2012:12	London Metal

metric tonnes Warehouse Stocks Metric Tonnes				Exchange
Lead London Metal Exchange Warehouse Stocks Lead Index	Global	Monthly	1987:7-2012:12	London Metal Exchange
Soybean Oil 1000 Metric Tons Ending Stocks	United States	Monthly	1994:12-2012:12	USDA
Soybean Meal Ending Stocks 1000 Metric Tons	United States	Monthly	1994:12-2012:12	USDA
Cocoa Metric Tonne	Global	Monthly	2002:1-2012:12	NYSE Liffe (London International Financial Futures and Options Exchange)
Corn Ending Stock 1000 Metric Tons	United States	Monthly	1994:12-2012:12	USDA
Global Green Coffee Stocks to Use-Days	Global	Monthly	1997:1-2012:12	F.O. Licht

Appendix C: Graphs of the macroeconomic and financial variables.



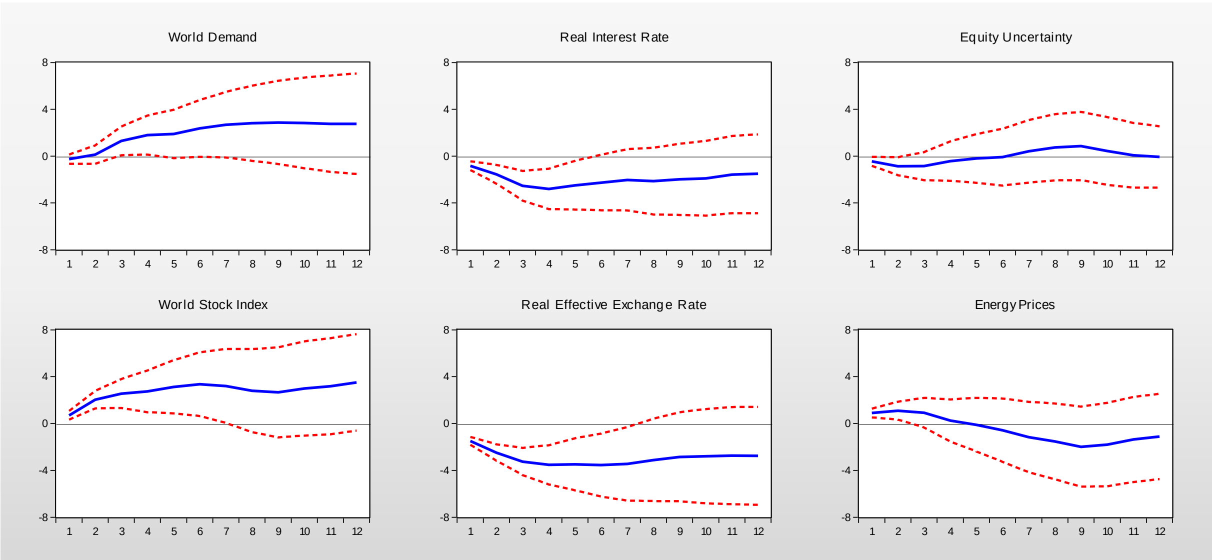
Appendix D: Residual Autocorrelation analysis of the FAVAR model. Lagrange Multiplier (LM) Test.

1992:2-2003:11	Test	Chi-sq	p-value
	LM(1)	χ^2 (49)= 44.49	0.6563
	LM(2)	χ^2 (49)= 43.09	0.7101
	LM(3)	χ^2 (49)= 51.92	0.3605
	LM(4)	χ^2 (49)= 44.26	0.6651
	LM(5)	χ^2 (49)= 47.06	0.5517
	LM(6)	χ^2 (49)= 39.49	0.8318
	LM(7)	χ^2 (49)= 48.78	0.4820
	LM(8)	χ^2 (49)= 38.42	0.8616
	LM(9)	χ^2 (49)= 50.33	0.4099
	LM(10)	χ^2 (49)= 55.48	0.2436
	LM(11)	χ^2 (49)= 50.33	0.4202
	LM(12)	χ^2 (49)= 35.30	0.9292

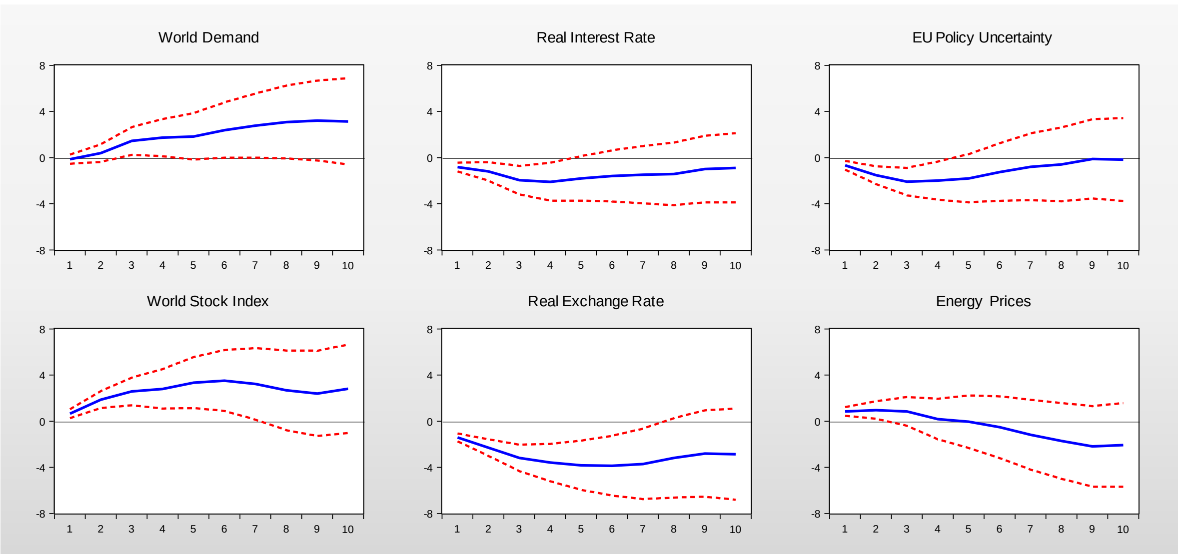
2003:12-2012:11	Test	Chi-sq	p-value
	LM(1)	χ^2 (49)= 55.26	0.2501
	LM(2)	χ^2 (49)= 47.01	0.5539
	LM(3)	χ^2 (49)= 46.43	0.5778
	LM(4)	χ^2 (49)= 50.03	0.4319
	LM(5)	χ^2 (49)= 60.54	0.1247
	LM(6)	χ^2 (49)= 49.22	0.4641
	LM(7)	χ^2 (49)= 39.56	0.8297
	LM(8)	χ^2 (49)= 56.75	0.2085
	LM(9)	χ^2 (49)= 52.42	0.3425
	LM(10)	χ^2 (49)= 43.87	0.6824
	LM(11)	χ^2 (49)= 55.29	0.2490
	LM(12)	χ^2 (49)= 46.67	0.5694

Appendix E: Robustness checks: different proxies for uncertainty.

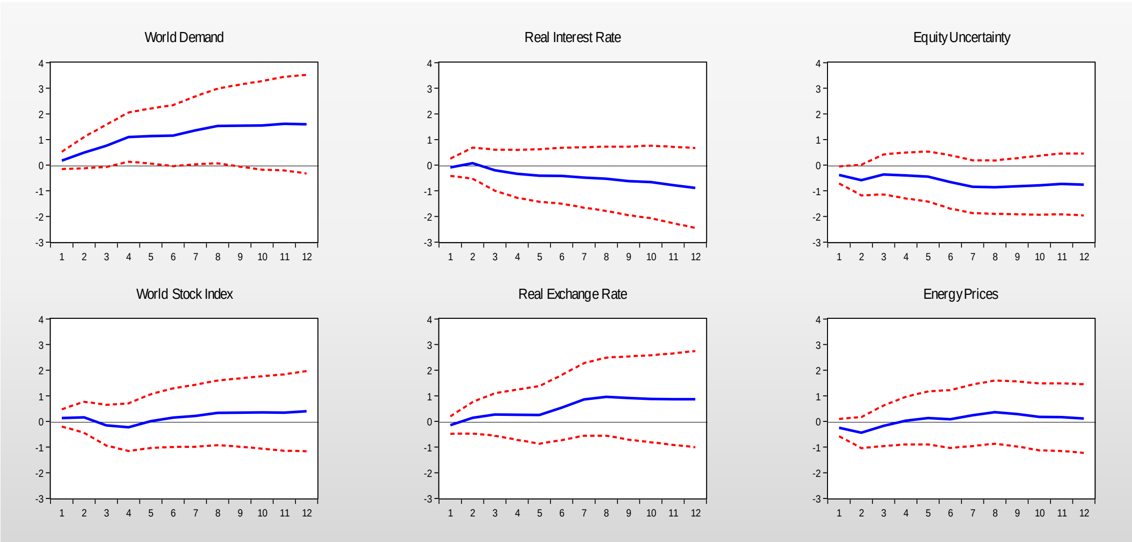
Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Uncertainty is proxy for the Equity Uncertainty Measure constructed by Baker, Bloom, and Davis (2012). Period 2003:12/2012:12



Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Uncertainty is proxy for the European Policy Uncertainty Measure constructed by Baker, Bloom, and Davis (2012). Period 2003:12/2012:12

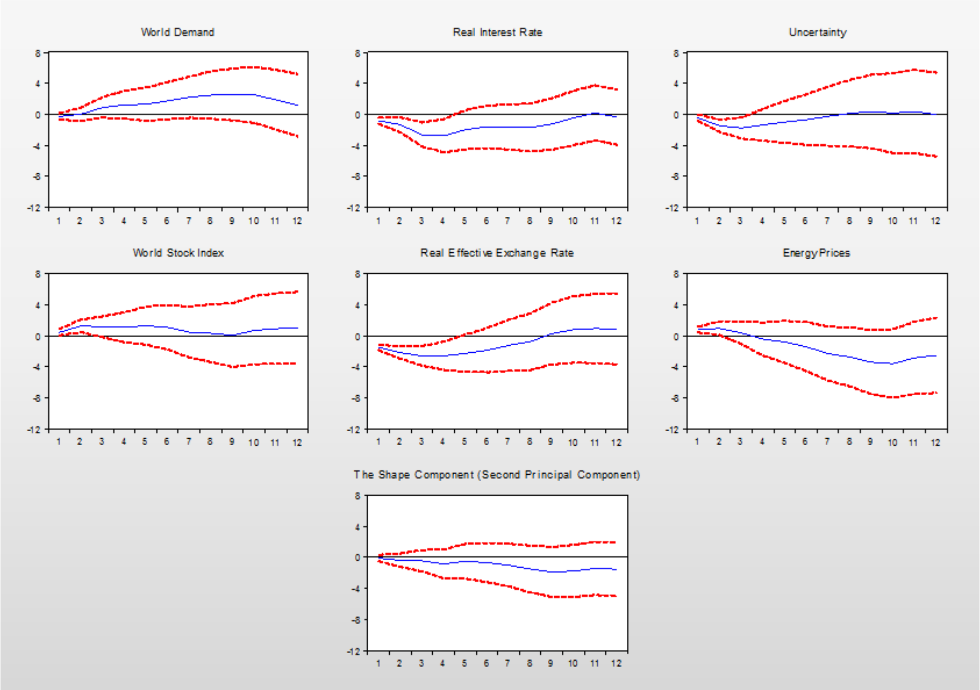


Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Uncertainty is proxy for the Equity Uncertainty Measure constructed by Baker, Bloom, and Davis (2012). Period 1992:2/2003:11

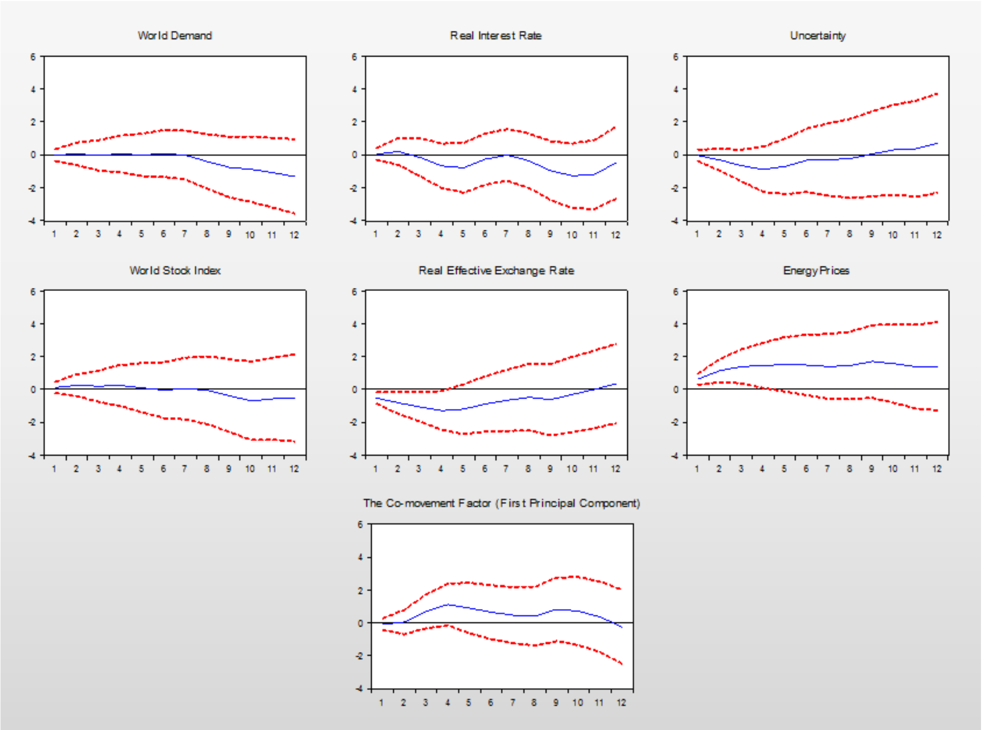


Appendix F: Robustness checks: FAVAR model with two non-fuel commodity factors.

Accumulated responses of the co-movement factor (first principal component) to shocks in macroeconomic and financial variables.



Accumulated responses of the Shape Component (second principal component) to shocks in macroeconomic and financial variables.



Chapter 3.

The predictive content of co-movement in non-energy commodity price changes

3.1. Introduction

In a recent study Poncela, Senra and Sierra (2013) found that there has been an increase in co-movement in a large range of non-energy commodity prices since 2004, perhaps enhanced by the financialization in the commodity markets . Thus, prices which should apparently not be correlated, increased their common evolution in time. According to this study, the variance of commodity prices explained by the common behavior of 44 non-energy commodity prices, jumped from 9% between February 1992 and November 2003, to 23% between December 2003 and December 2012. This means that after 2004 the common behavior of non-energy commodity prices accounts for a larger share of those fluctuations. It is therefore of interest to explore whether co-movement in prices of raw materials has some predictive power over each non energy commodity price.

To analyze the consequences of this stylized fact in forecasting, we compare several models against a baseline random walk alternative. We aim to explore the predictability of 44 non-fuel commodity spot prices measured on a monthly basis. For this purpose, we use a Dynamic Factor Model (DFM) to extract a latent factor that drives the co-movement on non-energy commodity prices. We evaluate two variants: a large-scale DFM that uses the whole commodity price data and estimate their co-movement through Principal Components and a small-scale DFM that takes into account the communalities into commodities of the same category and estimate factors by means of the Kalman filter. Our measure of forecasting performance is the out-of-sample root mean square error of prediction (RMSE) for one-step-ahead forecasts.

Although the literature on commodity price forecasts is extensive, it provides only scant empirical evidence of the role of co-movement in commodity prices as a possible source of predictability in non-energy spot prices. The recent literature has focused on evaluating whether macroeconomic and financial variables have some predictive power over commodity price spot indices, with mixed results. Chen, Rogoff and Rossi (2010) found that exchange rate fluctuations in a group of commodity-dependent countries have robust power in forecasting commodity price indices . Groen and Pesenti (2011) used a large set of macroeconomic variables, apart from exchange rates, to evaluate their predictive power over commodity indices. They did not find a robust validation of Chen et. al (2010)´s previous conclusions. Moreover, although the inclusion of multivariate macroeconomic variables improves the forecasts, it does not produce an overwhelming advantage of spot price predictability when compared with the random walk model. Gargano and Timmermann (2014) found that the predictability power of macroeconomic and financial variables depends on the state of the economy.

Another branch of the literature has focused on whether futures prices are good predictors of future spot prices. Chinn y Coibion (2013) evaluate the forecasts of a range of commodity prices finding that futures prices for precious and base metals display very limited predictive content for future price changes. In contrast, futures prices for energy and agricultural commodities do relatively better in terms of predicting subsequent price changes. In regard to oil prices, Alquist and Kilian (2010) use two models: one that considers the current level of futures prices as the predictor and the second which is based on the futures spread, to conclude that oil futures prices fail to improve on the accuracy of simple no-change forecasts.

Our paper considers the following research questions: First, does co-movement in non-energy commodity prices has predictive power over non-energy commodity prices? Second, has co-movement in commodity prices by category added power to the prediction in comparison with the large scale co-movement in commodity prices? Third, does the predictability of commodity prices vary across different types of categories, such as agricultural versus raw industrial commodities? We aim to answer these questions using dynamic factor models.

The paper is organized as follows. In section 2 we present the different models we estimate. In section 3 we describe the data and the methodological procedure we propose. In section 4 we report the estimation and forecasting results. Finally, in section 5 we conclude.

3.2. Model specifications

The first two models are limited to the information embedded in each commodity price time series itself: the first is a random walk model, used as benchmark, and the second is a univariate autoregressive (AR) model.

Let $P_{i,t}$ be the spot price of the *i-th* commodity at time t, i=1,…n and $t = 1, \ldots \ldots, T$. Then $y_{i,t}$= ln($P_{i,t}$)-ln($P_{i,t-1}$) denotes its related non-energy commodity price inflation. Then, the unconditional mean benchmark model is:

$$y_{i,t} = \alpha_i + \epsilon_{i,t}, \qquad (3.1)$$

which implies that the best forecast of the spot price of commodities is simply the current spot price plus the drift α if it were different from zero.

The AR(p_i) model for the *i-th* commodity, *i=1,….,n* follows the specification:

$$y_{i,t} = \alpha_i + \beta_{i,1} y_{i,t-1} + \cdots + \beta_{i,p_i} y_{i,t-p_i} + \epsilon_{i,t}, \qquad t = 1, \ldots, T. \qquad (3.2)$$

The subsequent models include a latent variable, or factor, that represents the common pattern of commodity prices. The general DFM specification assumes that the *i-th* commodity price inflation, labelled as y_{it}, is driven by a latent component, f_t,which is common to all series plus an idiosyncratic component, $\varepsilon_{i,t}$[11]. For instance, specific to each i we obtain:

$$y_{it} = \lambda_i f_t + \varepsilon_{i,t}, \qquad \forall i \qquad i = 1, \ldots, N \qquad (3.3)$$

where λ_i is the loading of the common factor into the *i-th* commodity. Accordingly, the factor base regressions, related to the large-scale DFM follow the specification:

$$y_{i,t+1} = \beta_i f_t + u_{i,t+1} \qquad (3.4)$$

We also evaluate whether the inclusion of the forecast of the idiosyncratic component of the DFM, $\varepsilon_{i,t}$, improves the forecasting performance, or it is only the forecast of the

[11] Although the DFM may have multiple factors, we have only identified the factor structure using the information criteria proposed by Bai and Ng (2002) which confirm that there is one factor in the commodity price data.

common part what is valuable for forecasting[12]. Then, the factor base regression related to the large-scale DFM that takes into account the idiosyncratic component follows the specification:

$$y_{i,t+1} = \beta_{1i} f_t + \beta_{2i} \varepsilon_{i,t} + u_{i,t+1} \tag{3.5}$$

Besides estimating a large-scale DFM, which takes into account a single common factor to all the commodity price series (equations 3.4-3.5), in this paper we also estimate a set of small-scale DFM models by introducing dynamic factors which are common only to the series within each set. More precisely, let us consider *L* commodity categories, and for each category (category *l=1,2,…,L*) k_l commodity price series. Then, if we are interested in one-step-ahead predictions, the baseline model for each commodity price in the l^{th}category can be decomposed into the following components:

$$y_{i,t} = a_i^l c_{l,t} + \varepsilon_{i,t,}^l \qquad l = 1, \dots k_l, \qquad \forall i \;\; \forall l \tag{3.6}$$

where within each category *l*, $c_{l,t}$ is the factor or co-movement variable common to all series in the category, a_i^l represents the factor loading, and $\varepsilon_{i,}^l$ named idiosyncratic component, collects the dynamics specific to each commodity price inflation. Both the common factor and the idiosyncratic component may follow AR processes of order q and p_i, respectively.

$$c_{l,t} = \vartheta_{0,1}^l c_{l,t-1} + \cdots + \vartheta_{0,q}^l c_{l,t-q} + \eta_{0,t}^l \tag{3.7}$$

$$\varepsilon_{i,t}^l = \phi_{i,1}^l \varepsilon_{i,t-1}^l + \cdots + \phi_{i,p_i}^l \varepsilon_{i,t-p_i}^l + \sigma_i^l \eta_{i,t}^l, \tag{3.8}$$

[12] Currently, small-scale factor models also include the forecasting of the idiosyncratic component (see, for instance, Camacho and Perez-Quirós, 2010) while forecasting through large scale factor models only use the common factors embedded in a forecasting equation with own lags of the target variable to reproduce specific dynamics (see, for instance, Stock and Watson, 2011). The advantage of including the forecast of the idiosyncratic component instead of own lags of the target variable could be due to the fact that the idiosyncratic component is uncorrelated with the common factors. We aim to check the usefulness of the idiosyncratic component in factor forecasting with and without this component.

where σ_i is the standard deviation of the idiosyncratic component, and $\eta_{i,t} \sim N(0,1)$ $i = l, \dots k_l, l = 1, \dots, L,$ are the innovations to the law motions for equations (3.7) and (3.8), respectively. We also evaluate whether the inclusion of the forecast of the idiosyncratic component of the DFM improves the forecasting performance in the small-scale DFMs.

With regard to the estimation method for the large-scale DFM, we use Principal Components. The large number of commodities used to evaluate the factor in the large-scale DFM, allows us to assume consistency of the Principal Components estimator[13]. As regards to the small-scale DFMs, we estimate them in the state-space using the Kalman filter. The smaller number of variables involved in the factor models by category impedes us from using the estimator of principal components in this latter case. The Kalman filter also produces filtered inferences of the common factor that can be used in the prediction equation (3.9 and 3.10) to compute OLS forecasts of the variable $y^l_{i,t+1}$.

To sum up, the different models, and its variations, that we estimate and compare in terms of forecasting with the baseline random walk in this study can be summarized as:

1. Autoregressive (AR) model.
2. Large-scale DFM
   - 2.1. Large-scale DFM with idiosyncratic component.
   - 2.2. Large-scale DFM without idiosyncratic component.
3. Small-Scale DFM
   - 3.1. Small-Scale DFM with idiosyncratic component.
   - 3.2. Small-Scale DFM without idiosyncratic component.

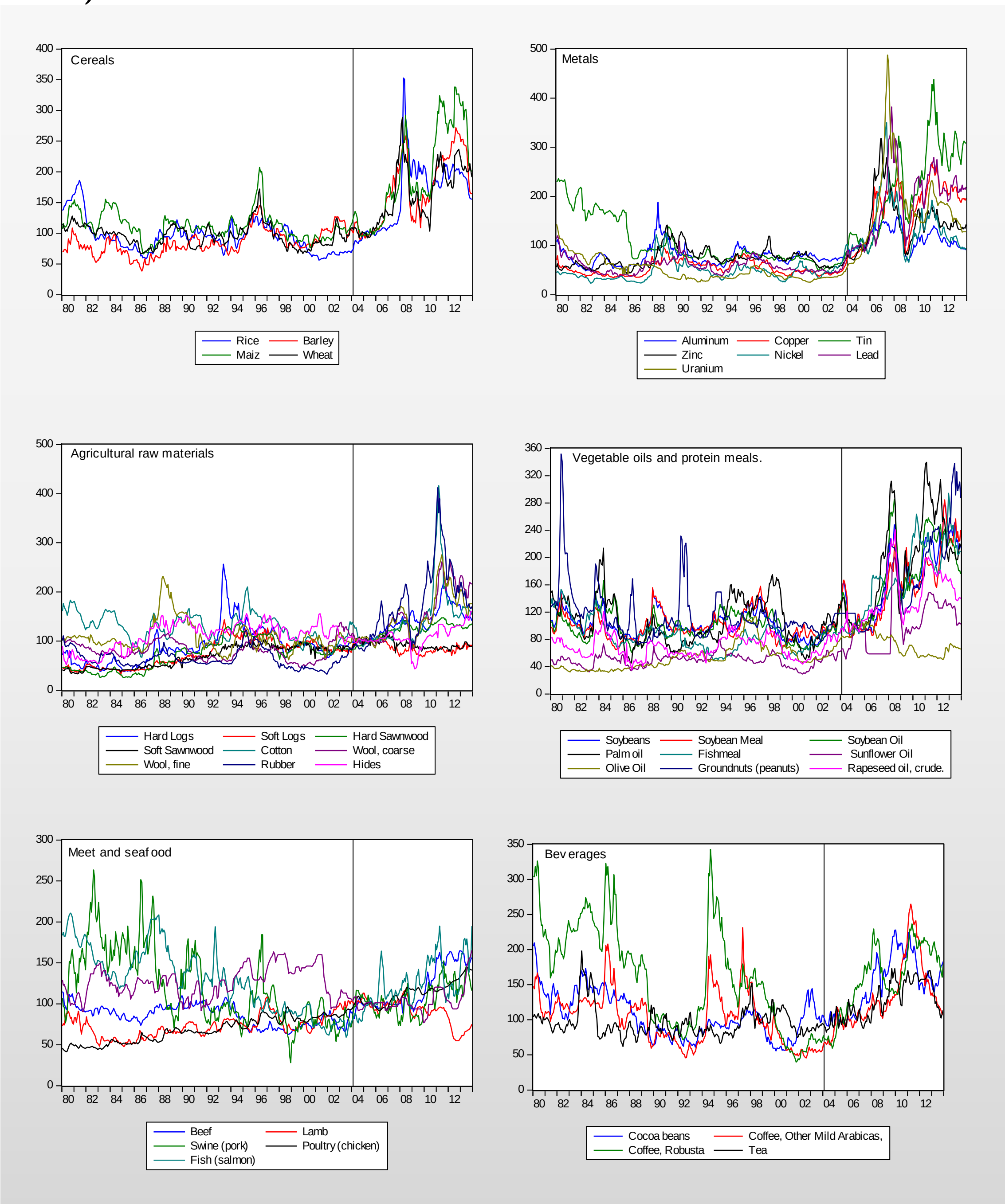
[13] For a discussion of dynamic factor models and its estimation methods, see for instance Stock and Watson (2011).

3.3. Data description and empirical strategy.

We use 44 monthly non-fuel commodity price series from the International Monetary Fund database (IMF IFS). In accordance with the increase in the co-movement in non-energy commodity prices found in Poncela, et al. (2013), we began our sample in January 2004 and finished in December 2013. We include in our study the raw materials available in the following categories: cereals, meat and seafood, beverages, vegetable oil and protein meals, agricultural raw materials and metals. A summary of the commodities and their categories is shown in appendix A.

Figure 3.1 presents the non-energy commodity prices per category from January 1980 to December 2013. The starting date of our sample, January 2004, is marked with a vertical line in all plots. Our sample is characterized by a great upsurge in several of the non-energy commodity prices until mid-2008, and a drastic decline during the global financial crisis. After mid-2009, prices began to recover the upswing in several of the categories, being remarkable: agricultural raw material, cereals and metals. Notably, if we compare both the pre-2004 and post-2004 samples, there is an increase in the scale of the boom and bust cycles for industrial inputs such as agricultural raw material and metals, and edibles such as cereals, vegetable oils and protein meals.

Figure 3.1: Non-energy commodity prices per category (2005=100, in terms of U.S. dollars).



Source: International Monetary Fund, IMF

Table 3.1 shows the descriptive statistics of the non-energy commodity price inflation for the period 2004:1-2013:12. Average inflations of non-energy commodities over the considered period are mostly positive, only three commodities have negative nominal average inflation (nickel, olive oil and lamb). The largest mean inflations correspond to metals such as copper and tin, with 0.98% and 1.10% per month, respectively. The biggest values of volatility also coincide with the metal category: nickel, copper and lead reports the greatest volatilities. Other commodities that exhibit large volatilities are: rubber, sunflower oil and swine (pork). The rest of the descriptive statistics show greater kurtosis than the normal distribution in all commodity price inflation while skewness can be either positive or negative. Finally, as it can be seen in bottom of table 3.1, the serial correlation term suggests first order autocorrelation is present in most of commodity prices, which justifies the first lagged term in equation (3.2).

Table 3.1: Summary statistics for non-energy commodity price inflation

Agricultural raw materials	Hard Logs	Soft Logs	Hard Sawnwood	Soft Sawnwood	Cotton	Wool, coarse	Wool, fine	Rubber	Hides
Mean (%)	0,317	0,146	0,421	0,065	0,144	0,556	0,495	0,588	0,325
Std. Dev. (%)	3,370	6,352	2,247	5,823	6,898	6,002	5,954	8,970	7,498
Skewness	0,032	0,304	-0,404	0,364	-0,623	-0,168	0,244	-1,061	-2,689
Kurtosis	3,927	3,803	4,781	5,936	6,606	5,817	4,397	6,159	27,844
AR(1)	0,332	0,362	0,133	0,330	0,401	0,345	0,333	0,267	0,199

Veg. Oil and Prot. Meal	Soybeans	Soybean Meal	Soybean Oil	Palm oil	Fishmeal	Sunflower Oil	Olive Oil	Ground-nuts	Rapeseed oil
Mean (%)	0,455	0,551	0,286	0,423	0,702	0,414	-0,166	0,739	0,377
Std. Dev. (%)	6,982	7,725	6,235	7,699	5,181	10,398	4,251	5,307	6,047
Skewness	-0,710	-0,663	-0,561	-0,788	1,297	2,384	1,175	0,050	-0,265
Kurtosis	5,135	5,030	4,615	5,810	8,056	21,403	6,786	6,061	4,743
AR(1)	0,334	0,316	0,361	0,433	0,297	0,417	0,261	0,288	0,235

Metals	Aluminum	Copper	Tin	Zinc	Nickel	Lead	Uranium
Mean (%)	0,061	0,989	1,103	0,587	-0,016	0,942	0,821
Std. Dev. (%)	5,823	8,112	7,508	7,847	9,864	9,204	7,233
Skewness	-0,608	-0,892	-0,317	-0,483	-0,340	-0,762	-0,430
Kurtosis	4,222	6,941	3,185	4,096	3,968	4,048	5,732
AR(1)	0,308	0,441	0,279	0,327	0,299	0,251	0,454

Beverages	Cocoa beans	Coffee, Arabicas	Coffee, Robusta	Tea
Mean (%)	0,450	0,558	0,777	0,150
Std. Dev. (%)	5,784	6,143	5,817	7,641
Skewness	-0,153	0,315	-0,051	0,071
Kurtosis	3,328	2,971	3,216	3,593
AR(1)	0,204	0,113	0,217	0,123

Cereals	Rice	Barley	Maiz	Wheat
Mean (%)	0,684	0,366	0,473	0,472
Std. Dev. (%)	6,899	7,165	7,086	7,268
Skewness	2,470	-0,364	-0,210	0,476
Kurtosis	16,131	5,316	4,559	5,027

AR(1)	0,521	0,295	0,226	0,225		
Meat seafood	Beef	Lamb	Swine (pork)	Poultry (chicken)	Fish (salmon)	Shrimp
Mean (%)	0,473	-0,268	0,399	0,344	0,775	0,371
Std. Dev. (%)	4,137	3,292	8,309	1,370	7,492	3,651
Skewness	-0,113	-0,285	0,036	-0,040	-0,241	0,707
Kurtosis	8,249	4,009	3,223	2,978	3,477	9,059
AR(1)	0,176	0,473	0,069	0,749	0,252	0,373

Once the different model alternatives have been exposed in the previous section, our procedure in analyzing the data is as follows:

1. Following Stock and Watson (2011), we log differentiated and standardized commodity price data, prior to the factor extraction either by Principal Components or Kalman filter.
2. We determine the number of factors of the large-scale DFM using information criteria proposed by Bai and Ng (2002). For small factor models we analyze the eigenstructure of their variance-covariance matrix to determine the number of factors.
3. We estimate the DFM through both principal components and the Kalman filter.
4. We generate one-step-ahead forecasts. We start our out-of-sample forecasts in 2010:12, re-estimate the models adding one data point at the time. In other words, we use an expanding window. The evaluation period is 2011:01–2013:12.
5. We compute the RMSE for each model to assess its forecasting performance.
6. We compare the RMSE of every model with that of the random walk.

3.4. Empirical results

In this section we evaluate the predictive content of co-movement for non-energy commodity inflations. In particular, we examine whether joint movements of commodity prices can be used as predictors of commodity price inflations.

Before estimating the above mentioned different factor approaches, we confirm the presence of only one factor, which we call co-movement, in both large-scale DFM and small-scale DFMs[14].

Results for the AR model, large-scale factor models as well as the small-scale models are presented in table 3.2. The table compares the forecasting results in terms of the ratio of the RMSE of every model over the RMSE of the random walk forecast. Hence, a ratio less than one means that the model improves the benchmark forecast, while values above one suggest the opposite. We evaluate the statistical significance of the out-of-sample predictability results using the test statistics proposed by Diebold and Mariano (1995).

The first column of table 3.2 shows the RMSE ratios of the AR model, while the second and third columns show the RMSE ratios of the large-scale factor model without and with idiosyncratic component respectively. The forecasting results for the AR model report that for 43 commodities the model improves the random walk; 24 of these improvements were significant at the 10 percent level according to the test of Diebold and Mariano (1995). In addition, for 38 commodities the large-scale DFM beat the random walk forecasts, although only for 16 of these the differences between both models are significant. We did not find any differences, in terms of number of

[14] In the Kalman filter specification, we allow one autoregressive lag in the state-space transition equation.

commodities that outperform the random walk predictions, between large-scale factor model forecasts that take into account the idiosyncratic component of the factor analysis and models that do not.

With regard to the small-scale factor models the results are more encouraging. Columns 4 and 5 in table 3.2 report forecasting performance of these models relative to the naïve random walk model. First and foremost, the small-scale factor models provide better predictions than the large-scale DFM approach and the AR model in most of the commodities within the categories beverages, vegetable oils and protein meals, as well as agricultural raw materials and metals, which means that co-movements by commodity category added power to predictions. In this categories, RMSE outperform by far both the AR and the random walk specification in most of commodities. Predictability results of the small-scale factor models for cereals and meat and seafood are mixed.

Table 3.2: Ratios of the RMSE of the univariate autoregressive (AR) model, large-scale and small-scale factor models over the RMSE of the random walk model for the period of analysis 2004:1-2013:12.

RMSPE Model/RMSPE random walk.	(AR) model	Large-Scale DFM (without idiosyncratic component)	Large-Scale DFM (with idiosyncratic component)	Small-Scale DFM (without idiosyncratic component)	Small-Scale DFM (with idiosyncratic component)
Cereals					
Rice	0.872*	1.002	1.004	1.634*	1.641*
Barley	0.956	1.094	1.103	1.565	1.565
Maiz	0.785*	0.799	0.802	0.723*	0.723*
Wheat	0.754*	0.756	0.757	0.755*	0.754*
Meet and seafood					
Beef	0.785	0.819	0.819	1.020	1.025
Lamb	1.042**	1.356**	1.357*	1.410*	1.406*
Swine (pork)	0.716*	0.709	0.709	0.298*	0.301*
Poultry (chicken)	0.934	1.267	1.267	6.666*	6.669*

Fish (salmon)	0.800*	0.804	0.805	0.303***	0.302***
Shrimp	0.971	1.155	1.155	1.154	1.147
Beverages					
Cocoa beans	0.825	0.856	0.858	0.674*	0.674*
Coffee, Other Mild Arabicas,	0.820***	0.832**	0.835**	0.630*	0.631*
Coffee, Robusta	0.788**	0.787**	0.792**	0.746*	0.749*
Tea	0.891*	0.927*	0.928*	0.928	0.926
Vegetable oils and protein meals					
Soybeans	0.810	0.846	0.849	0.561**	0.562**
Soybean Meal	0.808	0.837	0.838	0.437***	0.440***
Soybean Oil	0.800*	0.834	0.843	0.724*	0.724*
Palm oil	0.807**	0.814*	0.820*	0.465***	0.463***
Fishmeal	0.842**	0.899	0.899	0.520**	0.517**
Sunflower Oil	0.806**	0.812***	0.818**	0.609*	0.606*
Olive Oil	0.797	0.796	0.797	0.480**	0.482**
Groundnuts (peanuts)	0.782	0.681	0.681	0.338***	0.341***
Rapeseed oil, crude.	0.762*	0.787*	0.795*	0.792*	0.791*
Sugar, bananas and orange					
Sugar, European import Price	0.761*	0.723	0.725	5.770***	5.771***
Sugar, Free Market	0.812**	0.841***	0.841**	1.488	1.488
Sugar, U.S. import price	0.873	0.966	0.966	2.601**	2.601**
Bananas	0.795**	0.784**	0.788**	2.526**	2.526**
Oranges	0.807**	0.814*	0.820*	0.732	0.732
Agricultural raw materials					
Hard Logs	0.932	1.046	1.046	1.470	1.470
Soft Logs	0.515***	0.578***	0.578***	0.431***	0.432***
Hard Sawnwood	0.779*	0.788	0.790	2.207	2.207
Soft Sawnwood	0.711**	0.680**	0.680**	0.928	0.925
Cotton	0.833	0.854	0.857	0.550**	0.549**
Wool, coarse	0.813	0.843	0.845	0.696*	0.697*
Wool, fine	0.840	0.902	0.906	0.784	0.785
Rubber	0.788	0.795	0.803	0.521***	0.522***
Hides	0.710	0.666	0.667	0.666	0.669
Metals					
Aluminum	0.761***	0.736**	0.740**	0.640	0.641**
Copper	0.820*	0.856	0.865	0.749	0.750*
Tin	0.787	0.795	0.800	0.457	0.457***
Zinc	0.752***	0.697***	0.699***	0.527	0.531***
Nickel	0.789	0.806	0.818	0.514	0.513***
Lead	0.749***	0.732**	0.737**	0.509	0.513***
Uranium	0.899	1.081	1.086	1.083	1.067

Notes: This table reports the ratio of the root mean square error of prediction of the models, to the root mean square error of prediction of the random walk model, $RMSPE_{Model}/RMSPE_{random\ walk}$. Values smaller than one indicate that the model perform better than the random walk. We compute the Diebold-Mariano (1995) test statistic for the null hypothesis that the corresponding MSE differential is zero.
*** Indicates statistical significance at the 1% level.
** Indicates statistical significance at the 5% level.
* Indicates statistical significance at the 10% level.

3.5. Robustness checks

As a robustness check we estimate all models for a prior period (1992:2-2003:12) and compare their forecasting performance, in terms of RMSE ratios, with the second period in order to assess whether commodity prices were more or less predictable in different subsamples. Results for the AR model, large-scale factor models as well as the small-scale models for the first period are presented in appendix B.

The methodology for estimating each model is the same as described in previous sections. Regarding the first period, we begin the out-of-sample forecasts in 2000:12, therefore, the evaluation period is 2001:1-2003:12. We follow the same procedure explained in section 3, and use an expanding window with a size of 36 months. We compare the predictive content for every model *i* in both of the periods (pre-2004 and post -2004) by means of the following difference:

$$\left(\frac{RMSE_{model_i}}{RMSE_{RW}}\right)_{pre-2004} - \left(\frac{RMSE_{model_i}}{RMSE_{RW}}\right)_{post-2004} \qquad (3.9)$$

When there is a value over one in the above difference, the predictive content of the model is enhanced in the second period, given that the RMSE against the random walk model is lower in the post-2004 period compared with the pre-2004 period.

In general, small-scale models both with and without idiosyncratic component, performed better in the second period. In the post-2004 period, compared to pre-2004, the small-scale models with and without specific component improved their prediction versus random walk in 28 commodities. Importantly, the ratio between the RMSE of the small-scale DFM to the RMSE of the random walk reduced more for commodities in the categories of vegetables and protein meal, agricultural raw materials, and metals. These results suggest that the increase in the overall movement of non-energy commodity prices since 2004 has causes the small-scale dynamic factor models to improve their predictive content.

Regarding the AR model, as well, as the large-scale DFM we found inconclusive results since approximately half of commodities´ prediction improved with these models and half worsened for the second period.

In addition to the comparison between periods of each model, we perform an analysis of the different models in each period. That is, we compare the forecasting performance among models, in terms of their RMSE ratios, in order to assess which model has the best behavior in each period. Specifically, we compare the predictive capability between models i and j for each period by means of the following difference:

$$\left(\frac{RMSE_{model_i}}{RMSE_{model_j}}\right)_{pre-2004},$$

$$\left(\frac{RMSE_{model_i}}{RMSE_{model_j}}\right)_{post-2004} \qquad (3.10)$$

Values above one mean that the model j outperforms the model prediction of i, since j has a RMSE lower than RMSE of the model i, and vice versa. The results can be summarized as:

a. In both the first and the second periods, the AR model outperforms the large scale factor models in its ability to predict changes in the prices of non-energy commodities. The ratios of the RMSE of the large scale models to the RMSE of the AR model are lower than one in approximately 33 to 37 commodities.
b. Results show that the large-scale DFM model without idiosyncratic component performs better, in terms of predictability, than the large-scale DFM with idiosyncratic component for both periods. For the first period, for 32 commodities, the large-scale DFM without idiosyncratic component beats the model with this element, while for the second period, it does so for 38 commodities.
c. Regarding the small-scale models, in both periods the model without idiosyncratic component reports lower ratios to the small-scale DFM with idiosyncratic component. For the first period, for 31 commodities, the small-scale DFM without idiosyncratic component outperforms, in terms of forecasting performance, the small-scale DFM with idiosyncratic component. For the second period, it does so for 25 commodities.
d. While comparing the AR model with the small-scale DFM, we found interesting results. For the first period, say pre-2004, the ratios of the RMSE of the small-scale models over the RMSE of the AR model forecast were lower than one for 18 commodities (for both models with and without idiosyncratic component). In contrast, for the second period, say post-2004, the small-scale models increased their predictive content to overcome the AR model in 27 commodities for both models with and without idiosyncratic component).
e. As in the previous point, we found an increase in the predictability of small-scale DFM in the second period in comparison to the large-scale DFM. That is,

pre-2004, the large-scale model beats the small-scale DFMs in 23 to 24 commodities. In contrast, for the post-2004 period, the small-scale DFM outperform the large-scale DFM in 30 commodities. Therefore it is only the common part what is informative for forecasting commodity returns.

These results reaffirm the increase in the predictive content of the small-scale factor models compared with both the autoregressive model and the large-scale DFM for the second period. In addition, the results in both forecasting sample highlight that for DFM, the inclusion of the idiosyncratic component does not improve the forecasting performance of these models in relation to the naïve random walk model. Therefore, it is only the common part what is informative for forecasting commodity returns.

3.6. Conclusions

To understand and predict changes in commodity prices it is important not only for commodity dependent countries, due to the fact that commodity price swings directly affect their term of trade and cycle, but also for commodity importing countries, because commodity prices impact inflation and may interfere with monetary policy goals.

We examine the predictability of non-energy commodity price changes when we take into account the co-movement of either a large range of commodities, or the co-movement within a specific category of raw material prices. We use a dynamic factor model approach and estimate the communalities of non-energy commodity price inflations either by Principal Components, for the case of large-scale factor, or Kalman Filter, in the case of the small-scale (category) factor.

We found that co-movement in extensive data of commodity prices has poorer predictive power over non-energy commodity prices since 2004 when comparing to the small-scale factor models and univariate AR model. Conversely, communalities into categories such as oils and protein meals, as well as metals seem to substantially improve the forecasting performance of the random walk model. For these categories we found reductions in the RMSE up to 50%. In the robustness checks, we found that small-scale DFM has gained predictive power since 2004. In fact, in the previous period, say 1992:2-2003:12, the predictability of small and large-scale factor models were similar. Finally, adding the forecast of the idiosyncratic component did not improve the results and, therefore, it is only the common part what is valuable for forecasting.

Before 2004 non-energy commodity prices were quite stable, especially for industrial inputs such as agricultural raw material and metals, and edibles such as cereals, vegetables oils and protein meals. On the contrary, after 2004, assets allocated to commodity indices increased, leading to the so-called financialization in the commodity markets. This new feature generates not only greater synchronization among commodities (co-movement), but also introduces higher levels of uncertainty to the market. In this paper we have studied the predictive power of co-movement in non-energy commodity prices, further work should include the recent role of uncertainty in commodity markets as a possible source of predictability.

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Appendix A.

Non-energy commodity prices

IMF Category		Commodity	
Edibles	**Cereals**	Rice	Maiz
		Barley	Wheat
	Meet and seafood	Beef	Poultry (chicken)
		Lamb	Fish (salmon)
		Swine (pork)	Shrimp
	Beverages	Cocoa beans	Coffee, Robusta
		Coffee, Other Mild Arabicas,	Tea
	Vegetable oils and protein meals	Soybeans	Sunflower Oil
		Soybean Meal	Olive Oil
		Soybean Oil	Groundnuts (peanuts)
		Palm oil	Rapeseed oil, crude.
		Fishmeal	
	Other Edibles	Sugar EU.	Oranges
		Sugar US.	
		Bananas	
Industrial Inputs	**Agricultural raw materials**	Hard Logs	
		Soft Logs	Wool, fine
		Hard Sawnwood	Rubber
		Soft Sawnwood	Hides
		Cotton	Wool, coarse
	Metals	Aluminum	Zinc
		Tin	Nickel
		Uranium	Lead
		Tin	

Appendix B.

Ratios of the RMSE of the the univariate autoregressive (AR) model, large-scale and small-scale factor models over the RMSE of the random walk model for the first period of analysis (1992:2-2013:12).

RMSPE Model/RMSPE random walk.	(AR) model	Large-Scale DFM (without idiosyncratic component)	Large-Scale DFM (with idiosyncratic component)	Small-Scale DFM (without idiosyncratic component)	Small-Scale DFM (with idiosyncratic component)
Cereals					
Rice	0.787*	0.8055	0.8057	1.515*	1.518*
Barley	0.8837	1.0290	1.0321	1.2524	1.2531
Maiz	0.808*	0.8382	0.8423	1.2262	1.2268
Wheat	0.8178	0.8438	0.8450	0.8387	0.8383
Meet and seafood					
Beef	0.8508	0.9003	0.9003	0.8226	0.8251
Lamb	0.744***	0.703**	0.703**	0.7629	0.7644
Swine (pork)	0.752*	0.7559	0.7558	0.356***	0.357***
Poultry (chicken)	0.9027	1.1232	1.1235	4.347***	4.350***
Fish (salmon)	0.826*	0.8704	0.8701	0.6469	0.6500
Shrimp	0.8298	0.8614	0.8615	0.8626	0.8627
Beverages					
Cocoa beans	0.8039	0.8181	0.8181	0.537**	0.537**
Coffee, Other Mild Arabicas,	0.749***	0.750**	0.750**	0.662**	0.665**
Coffee, Robusta	0.766**	0.769**	0.769**	0.565***	0.564***
Tea	0.750*	0.749*	0.749*	0.750*	0.749*
Vegetable oils and protein meals					
Soybeans	0.8535	0.8975	0.8997	0.9837	0.9849
Soybean Meal	0.8638	0.9037	0.9052	0.9742	0.9773
Soybean Oil	0.801*	0.8196	0.8213	0.7842	0.7836
Palm oil	0.790**	0.800*	0.802*	0.493***	0.490***
Fishmeal	0.810*	0.8386	0.8392	1.789**	1.791**
Sunflower Oil	0.798**	0.822*	0.823*	0.610**	0.608**
Olive Oil	0.8750	0.9302	0.9307	1.920***	1.918***
Groundnuts (peanuts)	0.9148	1.0494	1.0492	1.773**	1.772**
Rapeseed oil, crude.	0.790*	0.782*	0.785*	0.770*	0.769*
Sugar, bananas and orange					
Sugar, European import price	0.788*	0.8095	0.8100	1.380***	1.382***
Sugar, Free Market	0.730**	0.695**	0.695**	1.370*	1.373*
Sugar, U.S. import price	0.8751	0.9555	0.9556	1.894***	1.895***
Bananas	0.699**	0.694**	0.695**	0.613**	0.619**
Oranges	0.790**	0.800*	0.802*	0.8346	0.8251
Agricultural raw materials					
Hard Logs	0.9144	1.0898	1.0898	1.9059	1.9092
Soft Logs	0.476***	0.567***	0.566***	0.5902	0.5861

Hard Sawnwood	0.783*	0.8024	0.8021	2.1566	2.1591
Soft Sawnwood	0.494**	0.572**	0.572**	0.3779	0.3787
Cotton	0.8929	1.0721	1.0737	1.0255	1.0304
Wool, coarse	0.8874	0.9286	0.9286	0.8678	0.8680
Wool, fine	0.8314	0.8583	0.8588	0.6635	0.6645
Rubber	0.8112	0.8331	0.8333	0.7197	0.7201
Hides	0.9247	1.0384	1.0381	1.0388	1.0324
Metals					
Aluminum	0.741***	0.745**	0.745**	0.8209	0.8210
Copper	0.837*	0.8904	0.8913	0.8865	0.8868
Tin	0.8649	0.8942	0.8939	0.629*	0.629*
Zinc	0.742***	0.732***	0.733***	0.704**	0.704**
Nickel	0.8526	0.9184	0.9194	0.458***	0.459***
Lead	0.752***	0.743**	0.744**	0.539***	0.536***
Uranium	0.8780	0.9278	0.9279	0.9363	0.9304

Chapter 4.

Long-term links between raw materials prices, real exchange rate and relative de-industrialization in a commodity dependent economy. Empirical evidence of "Dutch disease" in Colombia

4.1. Introduction

The rise of the raw material sector can generate an increase in the national income and improvements in the balance of payments. However, it may also affect in a negative way the production of the export manufacturing sector. *Dutch disease* is frequently understood as the de-industrialization process of an economy, which is associated to the real exchange rate appreciation, produced as a consequence of an export windfall due to a resource discovery or a raw material export boom.

Lately there is an open debate in Colombia about the possible symptoms of *Dutch disease* due to the rise in the energy sector and the deep appreciation of the exchange rate. Colombia has been enjoying and at the same time suffering both phenomena over the last decade. High oil prices and flexible petroleum legislation in relation to the exploration of oil wells in 2003 have made Colombia a main exporter of petroleum today[15]. The post-2003 period coincides also with a drastic real exchange rate appreciation, one of the highest in the world[16]. Concern about the existence of symptoms of the disease in Colombia is, therefore, a valid issue.

The Colombian commodity export dependence, and its possible effect on de-industrialization of the country due to the appreciation of the exchange rate, motivates this research. Even though crude oil has not always been well ranked in exports, Colombia has historically been dependent on raw materials. The country experienced a bonanza in the prices of coffee, the former main export product in the mid-seventies. The coffee boom generated great resources from the exports, but it also affected the real exchange rate, which motivated similar debates about de-industrialization (see, e.g., Kamas, 1986 and Meisel, 1998).

This paper seeks to explore the evidence of symptoms of *Dutch disease* in Colombia in the long term. The Colombian economy presents specific features regarding this issue that makes this analysis distinctive. First, it has experienced two booms associated to two different commodities in two different periods of time: coffee and oil. Because of

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[15]In 2012, petroleum and its derivatives represented 53% of the total exports of Colombia, (National Administrative Department of Statistics-DANE).

[16]Between the years 2003 and 2011, the real exchange rate appreciated 52%, the seventh highest appreciation of the 95 countries the World Bank reports on.

that, it seems that the threat of *Dutch disease* in Colombia has been present along the years and makes relevant the analysis of the long term. As far the authors' knowledge, there is no econometric approach on *Dutch disease* in this country with a long enough span of data that covers the two historical export booms that Colombia has experienced. Notably, most papers center in the coffee boom (e.g. Puyana, 2000, Meisel 1998, Edwards, 1984 and Kamas, 1986) and do not examine the long term effects of a commodity windfall. More specifically, they do not analyze whether the adverse effects associated to *Dutch disease* offset the beneficial effects of commodity upsurge. Looking at the most recent export boom, associated with petroleum, the long term study of *Dutch disease* in Colombia is also crucial when analyzing the post-2003 appreciation trend in the country, jointly with an increase of 215% in real oil prices, Colombian main export product in that period. Monetary policy might be different if we expect that the upward trend observed since 2003 will not change in the short or medium term. Our paper focuses on the impact that the real prices of the two main commodities (coffee, petroleum) exported by Colombia in the period between 1972 and 2011, have had on relative manufacturing output, through the real exchange rate.

Second, there is no methodological consensus on how to research this phenomenon. Usually, articles are divided into two types. On the one hand, those that work with a large collection of cross-section data or short panels and use static or dynamic panel models; see Coudert, Couharde and Mignon (2011), Lartey (2007, 2011), Acosta and Mandelman (2009), and Kang and Lee (2011), and on the other, authors who use time series to find the relation between real exchange rate and several macroeconomic and financial variables; Benedictow, Fjærtoft, and Løfsnæs (2013), Beine, Bos and Coulombe (2012), Algieri (2011) and Egert (2008), among others. It is worth emphasizing that the country specific details related to *Dutch disease* are unexplored in cross-section studies. Furthermore, data and types of time series techniques differ according to the country of study.

Finally, although this paper makes no in-depth study of the policy implications, if the symptoms of *Dutch disease* were confirmed, policies should be oriented toward preventing industry dissolution and toward a better use of the resources coming from commodities. How to spend the revenues from the oil boom is crucial, not only to avoid *Dutch disease* effects, but also to take better advantage of the benefits associated with the positive income shock.

We estimate a Vector Error Correction Model (VECM) to explore the evidence of *Dutch disease* in Colombia, which enables us to find equilibrium relations among variables in the long term, based on the cointegration evidence. The cointegration concept, introduced by Engle and Granger (1987) and extended by Johansen (1991), consists on determining whether two or more variables come together in the long term, and how deviations may affect the short term.

We consider annual series between 1972 and 2012 to determine whether commodity prices are related to the real exchange rate and the ratio between manufacturing to services output in Colombia in the long term. We also take into account variables such as productivity, government expenditure, degree of trade openness and international inflows.

The rest of this article is organized as follows. Section two focuses on the description and definition of *Dutch disease* symptoms and offers an initial analysis of some of the key variables related to *Dutch disease* in Colombia. The econometric model is developed in section three. The last section offers conclusions and recommendations for economic policy.

4.2. *Dutch disease* and its symptoms in Colombia

The phenomenon known as *Dutch disease* refers to the negative effects on the manufacturing sector due to a large increase in a country income. The term was first used in an article in The Economist in 1977 to describe The Netherlands experience of discovering large gas deposits in the North Sea and their harmful effects on the manufacturing sector of the country.

The sudden increase of that country's wealth created an unprecedented inflow of capital, which produced an appreciation of its currency and, therefore, a loss of competitiveness of the non-gas exporting sectors.

The discovery of natural resource deposits and the increase in the price of these resources in the producing countries create great advantages, such as an increase in the country's wealth, greater fiscal income for social investment and an improvement in the balance of payments. However, the de-industrialization resulting from the loss of competitiveness may produce a high level of specialization in the production of the resource and in non-tradable sectors, which may leave the rest of the economy more vulnerable to external shocks with regard to international prices.

Corden and Neary's (1982) paper was the first to analyze the de-industrialization phenomenon produced by the boom of a sector which had been traditionally extractive from a theoretical view. The authors divide the economy into three sectors. Two of these produce internationally tradable goods. The first is the booming extractive sector (BS); like gas in The Netherlands, oil in Venezuela and minerals in Australia. The second is traditional manufacturing (MS), and the third is a non-tradable sector such as services and construction (NTS). The *Dutch disease* will result in a contraction in the traditional export sector (MS), through *spending* and *resource movement effects*.

In the *spending effect*, the competitiveness of the manufacturing sector is noted due to the real appreciation of the national currency, through the increase of either the nominal exchange rate or the national prices. To explain this aspect more clearly, let´s suppose that the country is currently witnessing a growth period in the export booming sector, which generates a huge influx of foreign currency. Supposing that the country has a flexible exchange rate regime, the windfall will generate appreciation of the local currency. On the other hand, the resource boom generates greater income to the government, through taxes and royalties, as well as directly to the owners of the factors. The subsequent increase in the demand drives up the prices of non-tradable goods[17]. Both the nominal appreciation of the local currency and the increase in local prices, generate a real appreciation of currency and a contraction in the traditional manufacturing sector (de-industrialization).

At a theoretical level, extensions of the Corden and Neary (1982) models have been developed and they illustrate the spending effect, including or modifying assumptions to the core model. Van der Ploeg (2011), for instance, takes the Salter (1959) and Swan (1960) model to illustrate, the effects of a resource boom in the overall welfare of the country. Other extensions are Neary (1988), who widens the model considering inter-sectoral duality; Neary and Purvis (1982), who evaluate the effects of a BS windfall taking into account a tradable sector which is intensive in capital; and Morshed and Trunovsky (2004) who create a dynamic model with adjustment costs in investment allowing free movement of capital among tradable and non-tradable sectors. In any of these models, the final effect is an increase in the relative prices of non-tradable goods, which leads to the expansion of the NTS and a contraction of the MS. In contrast, Buiter

[17]At this point two clarifications are necessary. First: the increase in the general price level occurs due to the rising prices of the non-tradable goods sector, as prices in the tradable sector are internationally set. Second: the elasticity of demand for non-tradable goods with respect to income must be positive to allow an increase in their demand.

and Purvis (1983) found, in a theoretical approach, that in the long run, manufacturing output responds in a positive way to oil shocks when the country is small and a net oil exporter. However, increases in the price of oil can have transitional negative effect.

Besides the spending effect discussed so far, there are also resource movement effects arising from natural resource boom (Corden and Neary, 1982). The de-industrialization occurs because of the usual appreciation of the real exchange rate (the spending effect), and also by the movement of labor from the manufacturing and the non-tradable sectors towards the resource sector (the resource movement effect). According to Corden (1984) if nominal wages are rigid this might increase unemployment. The factor reallocation among sectors has been dynamically modeled by Krugman (1987), Bruno and Sachs (1982), and Chaterji and Price (1988). Krugman (1987) introduce economies of scale to the core model. Bruno and Sachs (1982) simulate an infinite-horizon economy to search for the transitional dynamics of *Dutch disease* shocks, and Chaterji and Price (1988) include long-run unemployment effects.

Other authors, e.g. Egert (2008), consider that the boom in an extractive sector can also encourage both national and international investment in that sector. The capital inflow to the country energy sector, as a form of foreign direct investment, can accentuate the real exchange rate appreciation. Lartey (2008) finds that the relative de-industrialization can be produced by the capital inflow to the country, even if not necessarily related to the extractive sector. In other words, there is empirical evidence about the relation between real exchange rate appreciation and variables such as, foreign direct investment, the level of financial liberalization, remittances and foreign aid; see Guha (2013), Lartey (2011), Acosta and Mandelman (2009) Arellano et al. (2005), Prati and

Tressel (2005), and Nkusu (2004)[18]. Hence, *Dutch disease* may be triggered by deposits discovered in the energy sector, as a result of variations of international prices of extractive products or commodities, or as a result of capital inflows such as foreign direct investment, remittances and international aid.

To summarize, *Dutch disease* symptoms are mainly a real appreciation of local currency and zero increase, or even the decrease, of the manufacturing sector related to that of non-tradable goods or services (relative de-industrialization). For the later, we focus on the spending effect on the relative manufacturing output.

There are few articles regarding the effects of a booming resource sector in Colombia and, as mentioned before, most of them are related to the effects of coffee boom. Edwards (1984), Kamas (1986) and Meisel (1998) report the influence that the coffee boom had in the production of other tradable goods. Edwards (1984), in a theoretical model, shows that a coffee export boom will generally generate a short-run increase in money supply, inflation and real appreciation. Kamas (1986) show that most of the conditions associated with the *Dutch disease* occurred in Colombia during the years 1975-1980[19]. The author finds an increase in the production of non-tradable goods sectors such as construction and public works, residential income and government services. Moreover, the growth of manufacturing production decreased along that period. However, Kamas (1986) OLS estimations were not significant when analyzing a negative relationship between appreciation of the real exchange rate and manufacturing sectors. On the other hand, Meisel (1998) shows analytical evidence of *Dutch disease* in the first half of the twentieth century as a result of the rise in

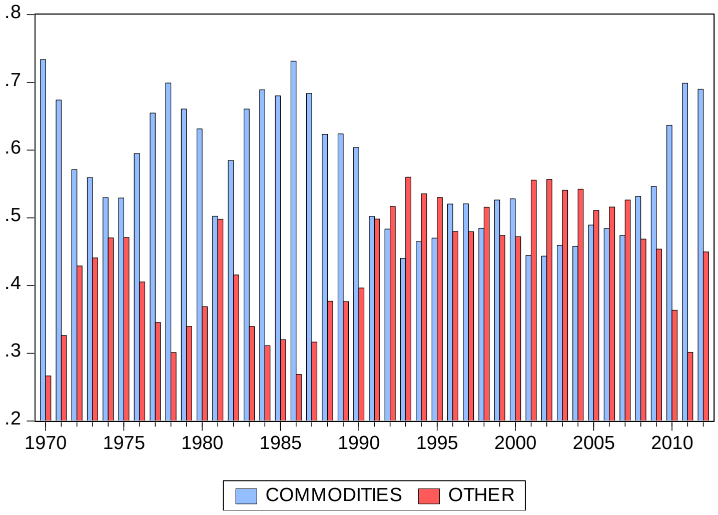
[18]Buiter and Purvis (1983) examine the relative importance of different shocks as sources of de-industrialization. Therefore, they search for the impact of an increase in oil prices, a domestic oil discovery, and monetary disinflation, over the real exchange rate.

[19]During these years the international coffee price abruptly increased as a result of frost in Brazil, which destroyed much of the crop and reduced the production capacity of the country.

international coffee sales. The author argues that appreciation of the real exchange rate was due to high coffee prices, sluggishness banana exports and limited economic growth of the Colombian Caribbean Coast. Suescún (1997) uses a neoclassical growth model to examine the influence of a shock in coffee prices on resource reallocation. The author finds temporary de-industrialization and appreciation of the real exchange rate. The effects of the oil discoveries during the nineties are shown by Puyana (2000) in a descriptive analysis about its possible effects on agriculture and rural poverty. As an oil exporting country, Colombia has been included in the *Dutch disease* cross country studies of Davis (1995) and Ismail (2010) on the effects in development and manufacturing, respectively. A summary table of the literature is presented in Appendix A.

Before examining each of the symptoms of *Dutch disease* in Colombia, it is important to highlight the participation of commodities in the total exports of the country. During the seventies and eighties, the exports in this type of goods represented on average 63% of total exports, see Figure 4.1. Only at the beginning of 1990 and 2000 fell their share in total exports under 50%. However, since November 2002, with the increase of international prices, their participation has begun to increase again and regained the 70% values of 1970.

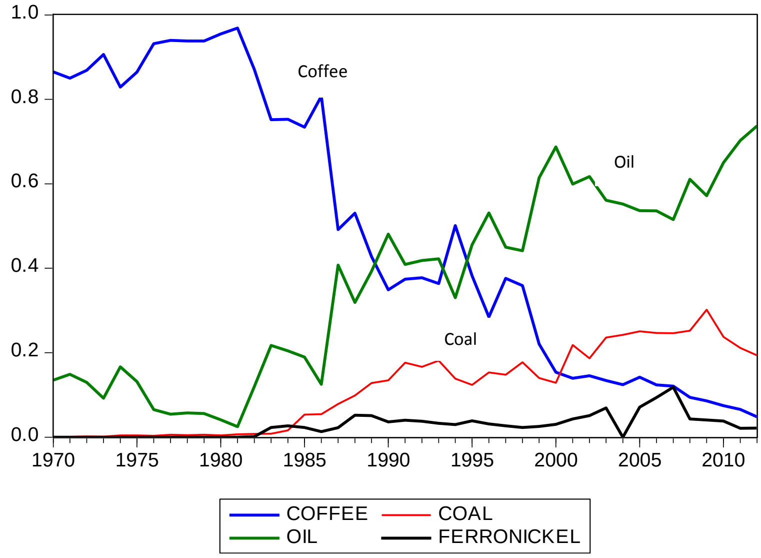
Figure 4.1: Commodity exports as a share of total exports in Colombia, percent, 1970-2011.



Source: National Administrative Department of Statistics, DANE, and Central Bank of Colombia.

Among commodities, the exports in Colombia are mainly concentrated in two kinds of goods: coffee and petroleum (see Figure 4.2). In the seventies and eighties, coffee had a participation in the exports of commodities that was always above 80%. The peak of coffee participation was in the year 1981, when it represented 97% of the total exports of commodities. Since that year, the importance of coffee has fallen in a dramatic way, and petroleum has gained a place in the export of raw materials. Likewise, coal improves its position in the basket of exported commodities.

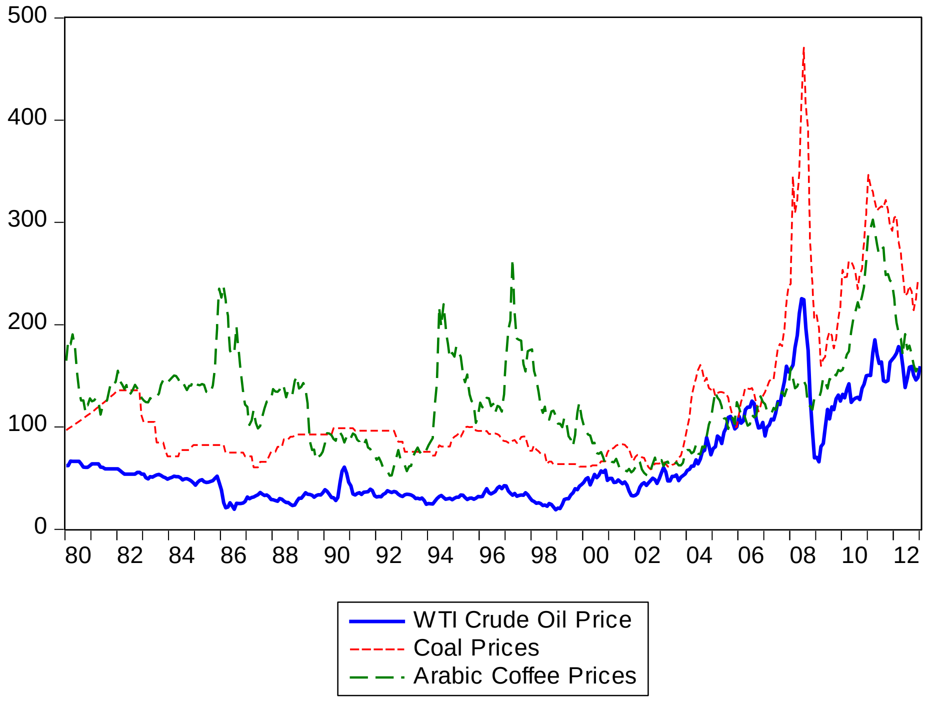
Figure 4.2: Commodity groups as a share of total commodity exports in Colombia (percentage).



Source: National Administrative Department of Statistics, DANE, and Central Bank of Colombia.

Even though one could think that the relative importance of coffee, coal and petroleum in the composition of the exports is marked by the evolution of their prices internationally, a simple graphic analysis does not seem to show it. As can be appreciated in Figure 4.3, the prices of the three main raw materials exported by Colombia increased since 2002, and they seemed to move together since then. The reason of the fall of the participation of coffee lies in a drastic reduction of the production of coffee since 1992. On the contrary, the production of oil and coal has an increasing trend since the mid-eighties, see Appendix B. The rise of the oil sector has been accentuated since 2003 when conditions to explore the country became less rigid with act 1760. With this flexibleness of the legislation, direct foreign investment towards the petroleum sector began to rise, see Appendix C. Therefore, the country received, on the one hand, currency from oil prices, and on the other, foreign direct investment.

Figure 4.3: Commodity prices in constant US$. 2005=100

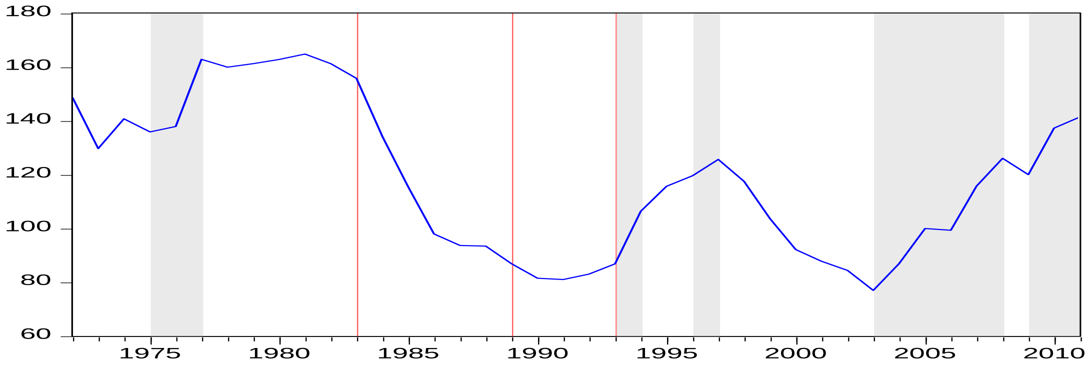


Source: International Monetary Fund, IMF.

After analyzing the importance of raw materials for the country exports, we focus again on the real exchange rate, one of the variables affected according to the *Dutch disease* hypothesis. Figure 4.4 shows the evolution of the real exchange rate since 1972. The color shade represents episodes of boom in the commodity exporting sector: the increase in coffee prices (1975-1977) and the increase in oil prices (2003-2008). The red lines identify the crude oil discoveries that made Colombia an oil export dependent country (Caño Limón in 1983, Cusiana in 1989 and Cuapiagua in 1993). When evaluating the real exchange rate from a historical perspective, it seems that huge increases in the main commodity exporting prices bring appreciation of the real exchange rate, while resource discoveries do not necessarily do so. While there was a pronounced real devaluation of the Colombian peso during the eighties, it was followed by different episodes of appreciation/devaluation. Therefore, the concern of the

Colombian non-traditional exporting sectors is due to the real exchange rate growth since 2003[20], its possible upward trend and the loss of share of the country's industrial exports.

Figure 4.4: Colombian Real Exchange Rate. 2005 = 100



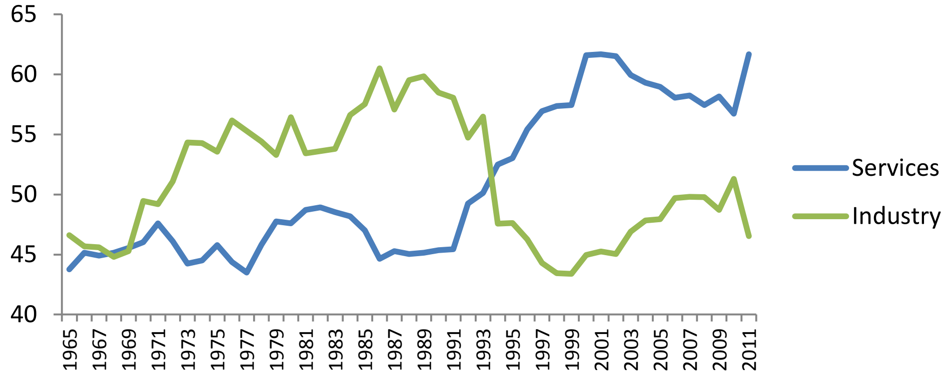
Source: IMF International Financial Statistics, and authors´ calculations.

Another symptom of *Dutch disease* is a zero increase or even the decrease of the manufacturing sector related to that of non-tradable goods or services (relative de-industrialization). Figure 4.5 displays the contribution of the services and industry sectors to the Gross Domestic Product (GDP). The graph shows that the largest loss in manufacturing value relative to services took place in the early nineties. Since 1994 the contribution of the service sector to GDP has been greater than that of the industrial sector, though the difference seems to have stabilized since 2000. A similar assessment can be deduced by analyzing only the portion of the industry related to manufacturing, see Figure 4.6. Despite the real appreciation taking place since 2003, manufactures do not seem to lose weight against the services during the first decade of the century. The loss of the relative manufacturing output coincides with the trade liberalization policies introduced in Colombia in the early nineties. The Colombian government in 1990 undertook an ambitious economic liberalization program. The economic openness

[20]From 2003 to 2011 the real exchange rate in Colombia has grown by 53% (IMF).

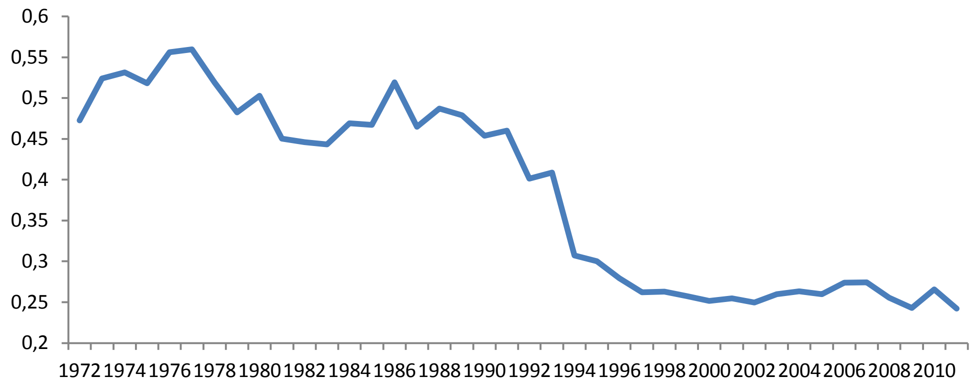
package reduced the average trade tariff from 34.5% to 11.4% in a year. Likewise, the effective rate of protection decreased from 60% to 26.2% at the end of 1990.

Figure 4.5: Contribution of the Sectors to the Gross Domestic Product (share).



Source: Data Service & Information. World Bank Statistics.

Figure 4.6: Ratio Manufacturing to Services. Value added in local currency.



Source: Data Service & Information. World Bank Statistics

4.3. Econometric modeling and empirical evidence of *Dutch disease* in Colombia

To assess the empirical relation between commodity prices and the *Dutch disease* symptoms in Colombia, we formulate a Vector Error Correction Model (VECM). Through VECM we can seek long run as well as short run effects of *Dutch disease*, if they exist.

The model will seek the estimation of two equations related to the main symptoms: 1) deterioration of international competitiveness in Colombia related to the real appreciation of national currency, 2) the relative de-industrialization related to commodity prices. Due to the lack of higher frequency data, we consider the larger annual span available from 1972 to 2011[21].

The first equation considers the real exchange rate, RER, as a measure of competitiveness in international markets. An increase in RER or a real appreciation of the peso implies that the prices of local goods are more expensive than those from the rest of the world. In this sense, the competitiveness of Colombian products, compared with those of its competitors, would be reduced. A usual way of defining the real exchange rate is given by the following equation:

$$RER = S * \frac{P}{P*}, \qquad (4.1)$$

where the real exchange rate (RER) is represented in the equation as the prices of domestic goods (P) relative to those from abroad (P*), adjusted by the nominal exchange rate (S). Based on this definition, we construct a proxy for the real exchange

[21] According to Otero and Smith (1999) the power to detect long run equilibrium relationships through, for instance, Johansen cointegration tests depends more on the total sample length than on the number of observations.

rate taking into account Colombian CPI and the US CPI, which is Colombia's main trade partner.

From an empirical point of view, the real exchange rate is related to sectorial productivity differentials (the Balassa-Samuelson effect), terms of trade, country openness to international trade and foreign capital inflows among other policy variables such as government spending (see, e.g., Edwards, 1989 and Alberola, 2003). The relationship between the real exchange rate and its determinants is expressed in equation (4.2).

RER=f(PRODUCT,COMM,*GOV*, OPEN, INFLOW). (4.2)

The relative productivity in the model, denoted by PRODUCT, is linked to the Balassa-Samuelson effect and it is proxied by the ratio between the consumer price index (CPI) to the producer price index (PPI). This approximation stems from the idea that non tradable goods are included in the CPI but not (or not much) in the PPI. Therefore, the Balassa-Samuelson effect, which relates productivity growth differentials to the relative price between non-tradable and tradable goods, should be caught through this variable. We followed in this approach the works of DeLoach (2001), Alberola(2003), Bénassy-Quéré et al., (2004). Commodity prices, *COMM*, are especially relevant when analyzing the *Dutch disease* symptoms in Colombia and can also be considered as a proxy variable of the terms of trade[22]. As shown in the previous section, the relative importance of coffee and oil in Colombian commodity exports changes over the period between 1972 and 2011. For this reason, we constructed a commodity price index taking into account their relative export weight in each year. With this, we aim to catch better the size of the commodity windfall. The increase in the international commodity

[22] This variable has been included recently by Coudert, Couharde and Mignon (2011), who analyze the long term relationship between the real effective exchange rate and the terms of trade for 52 commodity exporters and 12 oil exporters.

prices produces a surge of income through exports and an improvement in the terms of trade in commodity exporting countries like Colombia. In addition, the coefficient which accompanies this variable is expected to have a positive sign or a direct relation with the real exchange rate, since an increase in commodity prices would cause a real appreciation of the peso against the dollar.

The government expenditure, represented by the variable *GOV*, accounts for the share of government consumption in the GDP and it is expected to affect the country`s competitiveness positively as the government tends to consume more in non-tradable goods. Then an expansionary fiscal policy affects the national demand pushing prices of non-tradable up since they are the ones that are not international fixed[23].

The degree of openness, OPEN, defined as the ratio of imports plus exports to GDP, influences the long run real exchange rate negatively. Trade-liberalizing reforms that include, for example, reductions in tariffs, lead to a decline in the domestic price of imported goods that triggers an excess demand for imported goods and a reduction of domestic demand for non-traded goods. As a result, the real exchange rate depreciates to restore the equilibrium in the non-traded market.

The last variable in the equation is that related with the foreign capital inflows, denoted by INFLOW, which is associated with real exchange rate appreciation in the long run. According to Corden (1994) a foreign capital surge affects the economy by raising the domestic demand for both traded and non-traded goods. On the non-traded goods market, this excess of demand has to match a proportional increase of the non-traded supply in order to ensure market equilibrium. This in turn leads to a rise of the price of non-traded goods and, furthermore, to a real appreciation. We used data of private

[23] According to Lartey (2007) the extent of the effect will depend on the marginal propensity to consume non-tradable goods. .

capital flow from the World Bank that account for both net foreign direct investment and portfolio investment. Detailed data descriptions are reported in Appendix D and the graphs of the data in Appendix E.

The second equation in our model is expected to prove the relative de-industrialization due to a surge in commodity prices,

MAN_SERV = F (RER, PRODUCT, OPEN, INFLOW,GOV). (4.3)

We include, as a dependent variable, the ratio between Colombia manufacturing production to services production (*MAN_SERV*). Hereinafter, this relation will be referred to as relative manufacturing output. If there is, indeed, evidence of *Dutch disease* in the country, it is expected that the real exchange rate, *RER,* will have a negative effect on the relative manufacturing output. Increases in the real exchange rate, a real appreciation, will cause a loss of the country competitiveness that leads to a contraction of manufacturing exports and a contraction of manufacturing output. In equation (4.3), relative manufacturing output is also related to productivity, openness, private inflows and government spending. The variable productivity reflects the outsourcing process of the developing economies. The constant increases in productivity in these countries will eventually result in the strengthening of the services sector in relation to the manufacturing sector. Thus, it can be assumed that productivity has a negative sign. One of the explanations for this relation is based on the greater exposure of economies to international trade[24]. We include in the last equation the variable openness, OPEN, with the aim of testing the common view that commercial liberalization had brought about a de-industrialization process, or if contrary to this

[24]As long as the countries grow, and trade with more competitive countries in terms of manufacturing, the prices of these products will drop on the national market. Domestic producers will be forced to improve their productivity or withdraw from the market. The services sector is not exposed to international trade, and so benefits to the extent that the country grows and opens its doors to international trade; see Kang and Lee (2011).

view, trade openness benefits manufacturing by increasing international demand. We also want to see if financial liberalization, proxied in our analysis by Private Inflows, INFLOW, has positively affected the manufacturing production, as suggested by Kang and Lee (2011). On the other hand, as government spending, GOV, tends to allocate more towards non-tradable goods, so we can expect that an increase in this variable benefits more the service sector, so reducing the ratio MAN_SERV.

4.3.1. Order of integration

Before estimating the model, we perform the augmented Dickey-Fuller (ADF) unit root tests to check the number of unit roots in each time series. The variables related with the commodity prices, productivity, private inflows and relative manufacturing output were log-transformed. From now on we represent with capital letters the original variables and with lower case the log-transformed ones. The number of lags in the Augmented Dickey-Fuller test is based on Schwartz's information criterion. The results are shown in Table 4.1.

The analysis of the graphs in Appendix E, as well as the results of the tests in the previous table, suggest a need for at least one unit root for all series. The t-statistic and the p-values of the ADF indicate that the unit root null hypothesis cannot be rejected for all the series. Considering the first differences, the null hypothesis is rejected for the usual significance levels. Therefore, it is concluded that these series are integrated of order one, I(1).

Table 4.1: Unit root tests

	Augmented Dickey-Fuller test statistic			
	ADF in levels		ADF in first differences	
	t-Statistics	Prob.	t-Statistics	Prob.
Constant				
Inflow	-1.37791	0.2821	-3.68344	0.0008
GOV	-1.40317	0.5709	-4.82064	0.0004
Man_serv	-0.32524	0.9118	-3.65052	0.0093
Commo	-2.19290	0.2120	-7.06425	0.0000
OPEN	-1.67939	0.4335	-7.43676	0.0000
RER	-1.90978	0.3242	-3.13937	0.0327
Product	-1.03114	0.7319	-3.09833	0.0354
Constant and linear trend				
Inflow	-2.29349	0.1451	-3.66816	0.0000
GOV	-1.11901	0.9127	-4.80108	0.0022
Man_serv	-2.56762	0.2963	-3.56508	0.0470
Commo	-1.93562	0.6165	-6.95643	0.0000
OPEN	-2.47366	0.3386	-7.33044	0.0000
RER	-1.45163	0.8270	-3.35052	0.0749
Product	-2.52666	0.3143	-4.18595	0.0109

Null Hypothesis: There is a unit root.

4.3.2. Johansen analysis

The absence of stationarity in all the series implies that a co-integration analysis must be carried out, to analyze if the series are related in the long term. In this sense, we apply Johansen´s (1991) methodology and estimate a Vector Autoregressive model and test for cointegration. Table 4.2 shows the results of both trace and maximum eigenvalue cointegration test statistics for the linear trend option, as it seems to adjust best to data. To identify the lag length in the VAR, the Akaike Information (AIC), the Hannan-Quinn (HQ) and the Schwarz (SC) Criteria have been implemented. The chosen lag structure is one (the smallest value) following the SC and HQ criterion, as it also ensures that residuals are white noise. One dummy relative to 2009 has been included in the cointegration test to take into account the world economic crisis.

Table 4.2: Johansen Cointegration Test. Sample period: 1972-2011

Trend assumption: Linear deterministic trend							
Trace test				MaximumEigenvalue test			
Null Hypothesis	Alternative	Trace Stat.	Prob.**	Null Hypothesis	Alternative	Trace Stat.	Prob.**
r≤0*	r=1	185.1671	0.0000	r≤0*	r=1	65.29065	0.0002
r≤1*	r=2	119.8764	0.0004	r≤1*	r=2	48.61277	0.0044
r≤2	r=3	71.26365	0.0382	r≤2	r=3	29.19212	0.1638

* denotes rejection of the hypothesis at the 0.01 level
**MacKinnon-Haug-Michelis (1999) p-values

In Table 4.2, the trace statistic and the Maximum Eigenvalue test show the presence of two co-integrating relations with a significance level of 1%. The maximum eigenvalue statistic is located in two co-integrating equations at 5% and 1% significance level. Finally we consider two cointegration relations since this would be adopted at 1% significance level by the two tests and allows equations (4.2) and (4.3) to be estimated.

We also impose restrictions to identify the cointegration relation in equations (4.2) and (4.3). Therefore, the dependent variable for each co-integrating equation is imposed, giving the value of zero to the variables that are not included in each of the equations.

Results suggest that commodity prices (*Commo*) are co-integrated with the real exchange rate (*RER*) and with the relative manufacturing output (*Man_Serv*). The co-integrating relations can be formalized in the following equations, in which the standard errors are in brackets:

$$RER = -486 + \underset{(43.051)}{130.08}\, PRODUCT + \underset{(4.585)}{47.08}\, Commo + \underset{(0.205)}{0.68}\, GOV - \underset{(0.3506)}{2.31}\, OPEN - \underset{(2.426)}{14.01}\, Inflow \quad (4.4)$$

$$Man\_Serv = 1.84 + \underset{(0.002)}{0.007}\, RER - \underset{(0.811)}{0.21}\, Product + \underset{(0.051)}{0.07}\, Inflow - \underset{(0.038)}{0.025} GOV + \underset{(0.007)}{0.055}\, OPEN \quad (4.5)$$

Equations (4.4) and (4.5) are the estimated versions of equations (4.2) and (4.3), respectively. In this sense, equation (4.4) can be identified as a long run competitiveness equation and equation (4.5) as a long run relative manufacturing output equation.

As regards the model for the short run dynamics, we present our estimation results in Tables 4.3 and 4.4. The results that refer to the speed of adjustment of the long run equilibrium deviations or error correction term are shown in Table 4.3.

Table 4.3: Speed of adjustment

Error Correction	Δ(RER)	Δ(Commo)	Δ(Man_Serv)	Δ(GOV)	Δ(OPENESS)	Δ(Product)	Δ(Inflows)
Long-run competeveness equation	0.084 [0.897]	0.000 [-0.004]	0.000 [0.015]	-0.164 [-1.147]	0.042* [0.485]	-0.001 [-5.912]	0.009 [0.774]
Long-run relative manufacturing equation	27.647* [6.017]	0.198 [0.922]	0.006 [0.145]	-1.541 [-0.219]	-1.280 [-0.300]	-0.003 [-0.172]	-0.054 [-0.092]

Δ=1-L is the difference operator where L is the lag operator such that $Lx_t = x_{t-1}$.
t-statistics are in brackets and the p-value for the LR-test on the restrictions is 0.26.
*denotes significance at 5% level

As seen in Table 4.3, the first cointegration relation (long-run competitiveness equation) is affecting the short-run movements of $\Delta(Product)$, while it is not significant for the short-run dynamics of the remaining variables. In this sense, deviations from the long-term equilibrium of the real exchange rate impact on the short run movements of the ratio of non-trade to trade prices. The error correction term associated to the second cointegration relation (long-run relative manufacturing equation) is significant for the variable Δ (RER).

The short-run dynamics for Δ(RER) and Δ(Man_Serv) are reported in Table 4.4, The equations for the remaining variable in the model are given in the Appendix F. The real exchange rate is affected by commodity prices, the country's openness to international trade and the previous exchange rate in the short term. On the other hand, the relative manufacturing output is significantly affected by the variable, *RER*, which relates to the real effective exchange rate.

Table 4.4: VECM system short-run coefficients.

	$\Delta(RER)_t$		$\Delta(Man\_Ser)_t$	
	Coefficient	t-statistics	Coefficient	t-statistics
$\Delta(RER)_{t-1}$	-0.437	[-2.167]*	-0.004	[-2.164]*
$\Delta(Commo)_{t-1}$	10.550	[2.175]*	0.059	[1.399]
$\Delta((Man\_Serv)_{t-1}$	19.187	[0.963]	-0.268	[-1.546]
$\Delta(GOV)_{t-1}$	0.288	[1.903]	-0.001	[-0.408]
$\Delta(OPENESS)_{t-1}$	-0.788	[-2.939]*	-0.004	[-1.659]
$\Delta(Product)_{t-1}$	-24.553	[-1.011]	0.104	[0.494]
$\Delta(Inflows)_{t-1}$	-1.808	[1.213]	-0.008	[-0.516]
ECM_C_{t-1}	0.084	[0.897]	0.000	[0.015]
ECM_M_{t-1}	27.647*	[6.017]	0.006	[0.145]
C	0.707	[-1.013]	-0.018	[-1.910]
Summary statistics				
R-squared	0.763		0.614	
Adj. R-squared	0.663		0.451	
S.E. equation	6.079		0.053	

t-statistics are in brackets. ECM_C_{t-1} and ECM_M_{t-1} are the residuals of the Long-run competitiveness equation and long-run relative manufacturing equation, respectively.

The properties of the residuals of the estimated model have been analyzed (see Table 4.5). The system residual Lagrange-Multiplier test for autocorrelation shows that the null of no residual correlation cannot be rejected. The null hypothesis of normality for the residuals is tested through the joint Jarque-Bera test and cannot be rejected at the usual significance levels.

Table 4.5: Residual tests for the VECM system.

	Test	Chi-sq	p-value
Autocorrelation	LM(1)	χ^2 (49)= 49.91	0.4366
	LM(2)	χ^2 (49)= 54.62	0.2695
	LM(3)	χ^2 (49)= 45.64	0.6101
	LM(4)	χ^2 (49)= 56.65	0.3003
	LM(5)	χ^2 (49)= 38.06	0.8708
Normality		χ^2 (14)= 6.678	0.6179
Heteroskedasticity: no cross terms		χ^2 (560)= 533.02	0.7880

Note: Normality is based on joint Jarque-Bera test; orthogonalization is based on Cholesky (Lütkepohl).

As a robustness check, the long run equations have also being estimated through the Engle and Granger (1987) single equation methodology. The main results regarding the symptoms of the *Dutch disease*, available from the authors upon request, remain the same.

4.3.3. Results analysis

Perhaps the first important result is related to the fact that there is evidence that commodity prices positively affect the real exchange rate, as the *Dutch disease* hypothesis predicts. In fact, an increase in the commodity price index of 1% produces a real appreciation of 0.47 dollars, "ceteris paribus", see equation (4.4) for the long-run competiveness. The real appreciation of the Colombian peso creates a loss of competiveness in international markets, since local prices are higher than their international competitors. Likewise, internal consumers replace the demand of expensive national goods with cheaper imports.

Regarding equation (4.4), or long-run competiveness equation, the majority of the signs are those expected in the theory and all the variables are significant. It is important to emphasize the *GOV* variable, which represents the share of government consumption in the GDP, as a one point increase in this relation produces a real appreciation of 0.64

dollars, “ceteris paribus”. Theoretically, the expenditure effect boosted by the government generates an increase in prices, which causes a relative price rise of local goods compared to international products (real currency appreciation). The variable that relates to the openness of the economy to foreign trade, OPEN, has a negative relationship with the real exchange rate, and a one percent increase in the trade to GDP ratio generates a real depreciation of 2.35 dollars. This result indicates that liberalization of commercial policy leads to real depreciations as an increase in the openness degree leads to a convergence of international prices.

Productivity is positively related to the real exchange rate. The model estimates that an increase of the country productivity of 1% causes a real appreciation of the currency of approximately 1.3 dollars, “ceteris paribus”. As a consequence of the increase in productivity, the salaries and the prices of local goods rise compared to those from abroad, thus creating real appreciation of the currency. Private inflows, *Inflow*, do not have the expected positive sign, however.

With respect to the relative manufacturing equation, see equation (4.5), no supporting evidence can be found that the real exchange rate, *RER*, directly affects the relative manufacturing output negatively in the long term. In fact, a one dollar real appreciation generates an increase in relative manufacturing output of 0.70%. Our result suggests that the symptom associated to *Dutch disease* that is related to the relative de-industrialization is not present in the Colombian case. It is important to note the variable MAN_SERV, is measured as the ratio of manufacturing production to services production. Thus, our results show that, in the long run, real appreciation does not cause the relative de-industrialization process in Colombia. The positive long-run relationship may be explained by:

a. There is no reallocation of factors within the sectors due to the movement of the real exchange rate, so real appreciation does not push production factors from manufacturing exporting sectors to the production of services.
b. The appreciation periods are often used by manufacturing companies to capitalize and become more productive. Real appreciation can generate a positive effect on capacity of industrial production when facilitating access to imported inputs and capital goods, as well as improve financing conditions abroad. Therefore, the reduction of competitiveness due to the real appreciation of the exchange rate can be compensated by an increase in manufacturing companies' productivity.
c. Abstracting from service production developments, a resource boom implies that the non-commodity exports must lose share in total exports. We actually see this since 2007 for the post-2003 commodity boom (see Table 4.6)[25]. However, it does not automatically imply a shrinking of manufacturing output. As Colombia is a small economy that takes the world price of manufactures as given, manufacturing output could be maintained with the increase of the domestic demand associated with the resource boom. Hence, competitiveness losses are compensated by gains in domestic demand. In fact, periods of appreciation coincide with increases in the GDP growth or GDP growth above the mean (see Figure 4.7). Moreover, for the manufacturing sector domestic demand is a more important market than the external one. For the period between 2000 and 2009, for example, domestic manufacturing sales represented about 83% of total sales (The National Administrative Department of Statistics, DANE)

[25] Long series on manufacturing exports are not available for Colombia, therefore, we could not include this variable in our model.

Table 4.6: Share of the different economic sectors on total exports. Colombia: 2003-2012.

	2003	2004	2005	2006	2007	2008	2010	2012
Manufacturing	53,64	54,48	52,35	53,59	56,33	47,73	37,56	29,84
Agricultural Sector	9,04	8,33	8,09	7,63	7,02	5,66	5,44	4,36
Commodities	37,32	37,19	39,56	38,78	36,65	46,61	57,00	65,79

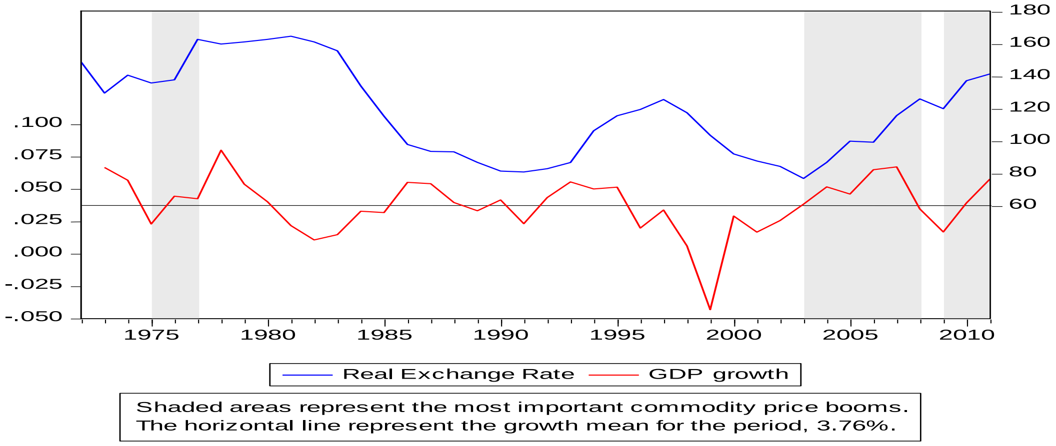
Source: National Statistics Office of Colombia ,DANE

We have checked for the robustness of our results by replacing the variable RER by COMM in equation (4.5) of the VECM. Our results (signs and significance of the variables) are not altered by this change, see Appendix G.

Although there is a positive long-run relationship between the real exchange rate and relative manufacturing output, in the short run the negative effect prevails (Table 4.4). The loss in competitiveness may be affecting exports and production in the last resource boom, 2003-2011. In fact, the increase in commodity price has been the more lasting in our period of study (in eight years the real price of the commodity price index increased by 225%). Besides, it is important to note the role of oil as intermediate good. In the short run, as manufacturing uses oil as input, there is a transitory loss of output as a result of the oil price surge that reinforces the competitiveness losses due to real appreciation[26].Our results are in the line with the theoretical studies of Buiter and Purvis (1983).

[26]Since 1993, oil prices account for more than a half of the share in our commodity index. The importance of oil as intermediate good is therefore greater during the last commodity boom.

Figure 4.7: Colombian real exchange rate and GDP growth.



Source: IMF International Financial Statistics, and authors´ calculations.

Although the parameter associated to *productivity* has the right sign, it is not significant. Moreover, the variable *INFLOW* showed a non significant positive relation with the relative manufacturing output.

Other variables that significantly affect the relative manufacturing output in equation (4.5) are OPEN and GOV. One additional point in the ratio trade to GDP, that is the openness index, generates a 5.5% increase in the relative manufacturing output. Hence, a greater exposure to international trade benefits the manufacturing production. According to equation (4.4), the real exchange rate is negatively related in the long run to trade openness. This means that in the long run one of the determinants of a depreciated currency is a high degree of economic openness. It is normal, therefore, that an increase in this ratio, OPEN, upsurges manufacturing production by allowing a greater access to international markets and making them more competitive. On the other hand, the estimated coefficients of government expenses share in GDP, *GOV*, shows a negative relationship with relative manufacturing output. When the government increases its expenses by one per cent of GDP, the variable MAN_SERV decreases by 2.52%. This result confirms the idea that governments tend to spend more on non-tradable goods such as services, health and education, Lartey (2007). It is important to note that an expansionary fiscal policy negatively affects the competitiveness of tradable sectors by increasing the real exchange rate. Therefore, public spending is a major source of pressure on aggregate demand, prices and real exchange rate. In this regard, the government may indirectly weaken the competitiveness of manufacturing sector. This is in line with the Stokke (2008) results for the South African economy. According to his study an increased public consumption due to a resource boom caused a real exchange rate appreciation and led to an expansion of service at the cost of industrial tradable sector.

4.4. Conclusions and policy recommendations

The aim of this work was to find empirical evidence of the *Dutch disease* symptoms in Colombia, of a country that experienced first a boom in coffee and lately in oil. Since the variables in the analysis are not stationary, Johansen's (1995) cointegration approach was used to establish the equilibrium relations between them in the long term. A Vector Error Correction Model, VECM, has been estimated to determine whether commodity prices are related to the real exchange rate and the relative manufacturing output in time. Other variables suggested by the theory and included in the model are productivity, the ratio between the national government expenditure to GDP, and the degree of openness.

The VECM estimates show that there is co-integration evidence between the commodity prices, the real exchange rate and the relative manufacturing output. In this way, increases in oil price produce a negative effect on the country's competiveness, since national goods become more expensive, compared to those of the rest of world, or they appreciate in real peso terms. However, our results do not suggest that the real exchange rate significantly affect the relative manufacturing output in the long run. In fact, periods of booms in coffee and oil match with periods of real appreciations but relative de-industrialization. Our results show that relative de-industrialization that has been occurring through the decrease in the size of the manufacturing sector relative to services is not due to the appreciation moved by commodity prices. Further studies are needed to analyze what internal reasons drive this pattern.

Our results, which indicate that relative manufacturing has so far been spared the negative effects of commodity price increases, may provide only temporary relief for policymakers in Colombia. If commodity prices remain high in the future, the nominal and real exchange rates will continue to appreciate by putting pressure on non-commodity industries. Then, the competitiveness losses will overcome the productivity gains from capital replacement and local demand. Against this backdrop, policymakers would be well advised to implement structural measures aimed to prevent unproductive and pro-cyclical public expense. Our result shows that public spending is a major source of pressure on aggregate demand and real exchange rate. In this regard, the government may indirectly weaken the competitiveness of manufacturing.

Our results present great challenges at economic policy level. What to do then with the proceeds of resource boom? In the literature there are two main approaches: Hartwick's rule for sustainability, Hartwick (1976), and the permanent income approach, Medas and Zakharova (2009). The first is an extreme intergenerational altruism rule. According to this rule, all revenues from extractive activities are invested in financial assets abroad, whose returns are the only raw material source of government spending. The priority of this rule lies in the transfer of most of the commodity wealth for future generations. The benefits of this approach, which is followed by Norway, are that neither losses of competitiveness, nor relative de-industrialization may occur. The oil revenues are placed in a State Oil Fund, which reports directly to the central bank and those who invest resources in stock markets worldwide. Only the net income flow is delivered to the government.

The permanent income approach consists of spending the extractive wealth at a gradual pace so as to ensure the ongoing participation of each generation according to a social welfare criterion, or a fiscal rule previously defined by the society. Chile has a fiscal rule that takes into account periods of prosperity and periods of "lean" and is based mainly on the fiscal balance. In early 2009, this system allowed Chile to use the savings from previous budget surpluses to conduct anti-cyclical policy and deal with the impact of the international recession on the economy. The appreciation and relative de-industrialization can be avoided in this approach by saving a substantial fraction of the commodity related revenue windfalls. Moreover, the approach provides fiscal stability[27].

Although the two previous approaches, based on savings, have great benefits, the temptation to spend is great for a developing country like Colombia. Colombia's natural resource wealth can help seize the growth opportunity by serving directly as a key source of growth if properly managed. So the challenge of policy lies in saving enough to prevent relative de-industrialization and to direct public expenses into productive activities. But this opportunity will only be realized if windfall earnings are managed judiciously within a long-term horizon, avoiding the "voracity effect" – a more than proportional increase in discretionary fiscal spending in response to a

[27] In a recently article on Dutch disease for the Russia case Benedictow et al.(2013) found that saving oil revenues in, for example, a wealth fund may reduce procyclicality of fiscal policy and the risk of boom–bust cycles.

positive revenue shock, such as a commodity revenue windfall-, Tornell and Lane (1999).

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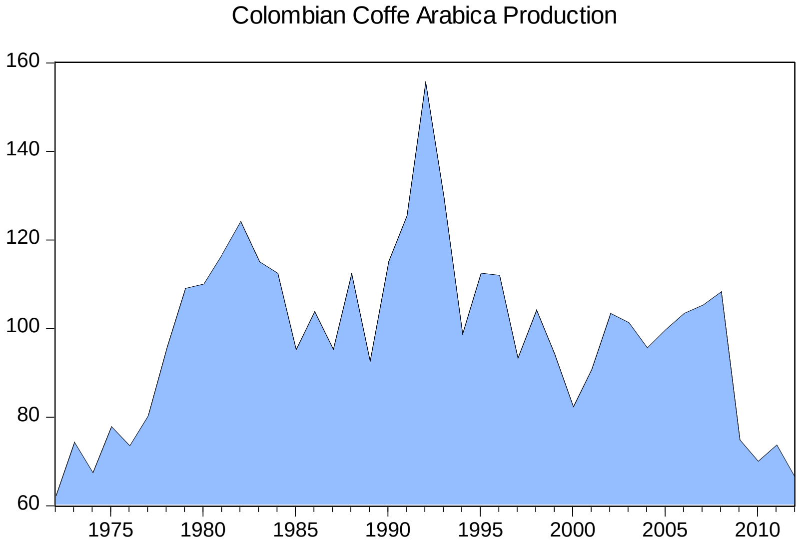
Appendix A: Summary of Dutch disease literature of Colombia

	Period of analysis	Booming commodity	Methodology	Evidence
Country specific studies				
Meisel (1998)	1891-1950	Coffee	Descriptive analysis	Coffee boom led to a squeezing out of the banana exports. Symptoms of the disease were observed mainly by the appreciation of the real exchange rate, and a decrease in exports and production in the banana sector.
Kamas (1986)	1975-1980	Coffee	Descriptive analysis and OLS	Non coffee exports were hurt by real appreciation. Growth rates for non-coffee and manufacturing exports fell during the period. In the OLS estimation, the real exchange rate affects positively but significantly the manufacturing output.
Puyana (2000)	1985-1997	Oil discoveries	Descriptive analyisis	Oil discoveries impact negatively on the agricultural sector.
Suescún (1997)	1952-1992	Coffee	Real Business Cycle (RBC) model	Find evidence of de-industrialization in a transient coffee shock.
Edwards (1984)	1952-1980	Coffee	Two and three stage-least-squares	Coffee price changes have been negatively related to the rate of devaluation and closely related to money creation and inflation.
Cross country studies where Colombia is included				
Davis (1995)	1970 and 1991	Oil	Descriptive analysis	According to the author, Colombia performed better, in terms of development indicators, than more commodity-dependent economies.
Ismail (2010)	1977-2004	Oil	Pooled least-square estimation with country	Find de-industrialization for Colombia in response to shocks in oil prices. However, the shocks have a lesser impact on Colombia due to the country´s lack of financial openness.

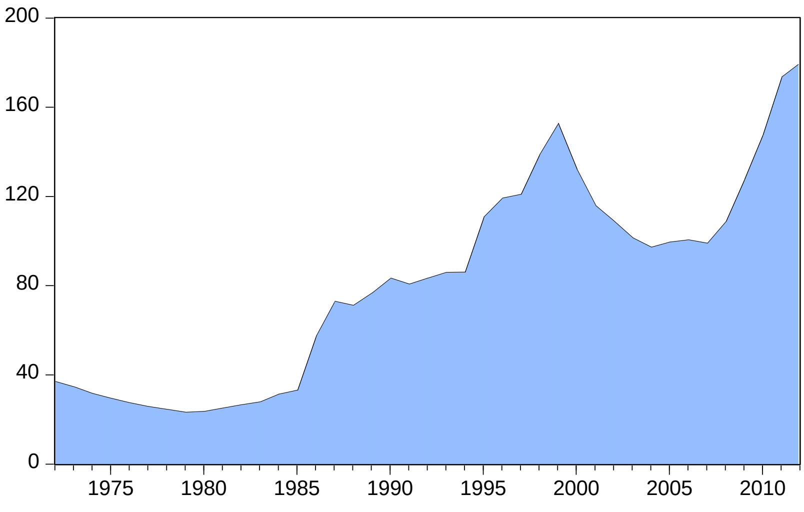
Appendix B: Commodities production and crude oil discoveries in Colombia.

Colombian Coffee Arabica Production, 60 kg bags (2005=100)



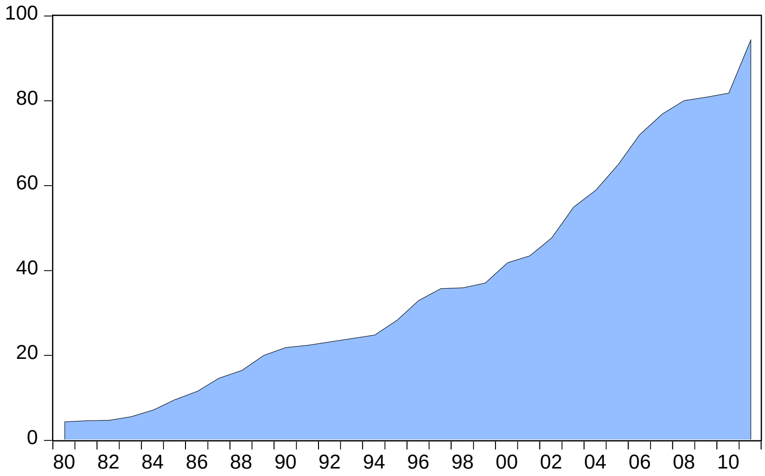
Source: United States Department of Agriculture, USDA

Colombian Crude Oil Production, 1000 barriles/day (2005=100)



Source: US Departament of Energy, DOE.

Colombian Coal Production. Million Short tones



Source: Source: US Departament of Energy, DOE.

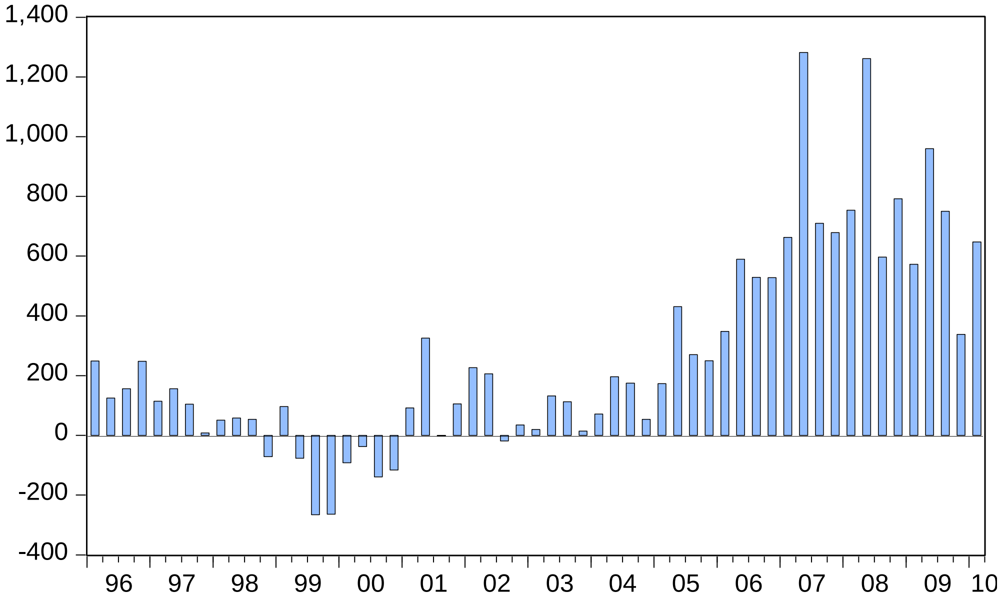
Major oil discoveries in Colombia

Name	Year of Discovery	Oil reservesMillionbarrels
La Cira-Infantas	1918	800
Tibú	1940	270
Casabe	1941	300
Velásquez-Palagua	1946	300
Yariguí	1954	200
Provincia-Payoa	1960	300
Río Zulia	1962	140
Orito	1963	240
Castilla	1969	320
Chuchupa	1972	7 GasCubicTerapies
Apiay-Suria	1981	215
Caño Limón	1983	1250
San Francisco	1985	150
Cusiana	1989	750
Cupiagua	1993	510
Guando	2000	130
Gibraltar	2003	630 Gas cubicGigapies 15 Millionbarrels

Source: ECOPETROL

Appendix C: Foreign Direct Investment in the petroleum sector. Colombia

Colombia BOP direct invest in colombian petroleum sector. Vlaue /millions. Dollars



Source: Central Bank of Colombia. Banco de la República.

Appendix D: Data sources

Real Exchange Rate *RER*. Authors´ calculations based on the Exchange Rate Index 2005=100 /Index Number /averages /exchange rate index /Cnt: Colombia /Source: IMF, Wash; CPI low & Middle Income Urban /Index Number /Base year: 2005 /averages /Cnt: Colombia /Source: IMF, Wash; and CPI all Items City Average /Index Number /Base year: 2005 /averages /Cnt: United States /Source: IMF, Wash.

Relative Manufacturing output *Man_Serv*: Ratio Manufacturing to services value added (current MN LCU) /Cnt: Colombia. Source: Data Service & Information. World Bank Statistics (2005=100).

The Balassa Samuelson or Productivity effect, *Product*. Proxied by the ratio of the consumer price index (CPI) to the producer price index (PPI). CPI low & Middle Income Urban and PPI / Wpi /Index Numbers /Base year: 2005 /averages /Cnt: Colombia /Source: IMF, Wash.

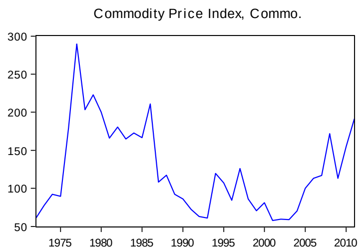
Government expenditure *GOV*: General government final consumption expenditure (% of GDP) /Cnt: Colombia /IMF, Washington. (2005=100).

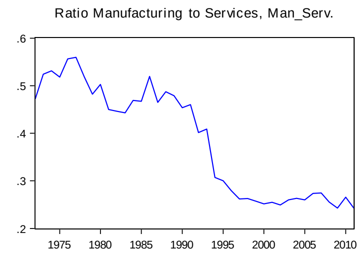
Real commodity prices, *Commo:* Authors´ calculations based on both oil and coffee prices and taking into account their relative weight on commodity exports since 1972 to 2011. The commodity prices are: The Cushing, OK WTI Spot Price (Dollres per Barrel). Source: Energy Information Administrator (2010), and the external price of Colombian coffee (exdock) /Cents per pound of 453.6 gr./annual average / sublime/source: Colombian Coffee Growers Federation. We deflected by US CPI (2005=100).

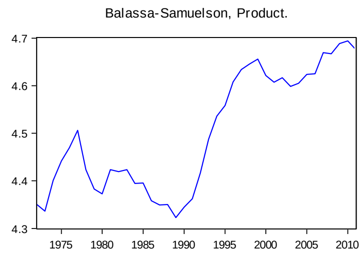
Openness, *OPEN*.Trade (% of GDP) /Cnt: Colombia/Source: IMF, Wash.

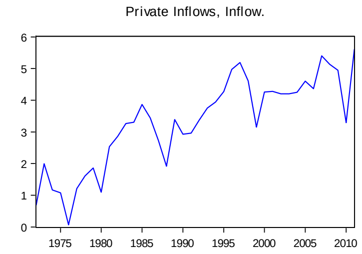
Private Inflows, *Inflow*. Private capital flows, total (BoP, current MN US$) /Cnt: Colombia/Source: IMF, Wash.

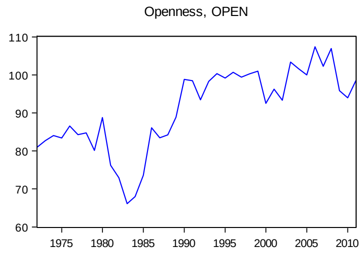
Appendix E: Graphs

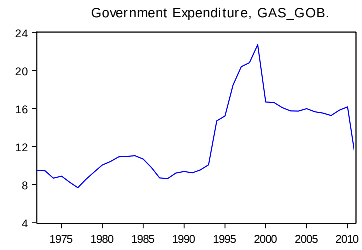


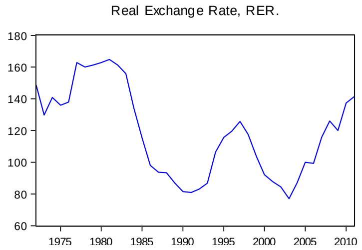












Appendix F: VECM system short-run coefficients of the rest of the variables of the model.

	Δ(GAS_GOV)	Δ(OPEN)	Δ(Commo)	Δ(Product)	Δ(Inflow)
Δ(GOV)t-1	-0.162 [-0.70163]	-0.082 [-0.58550]	0.012 [1.70384]	0.000 [-0.40311]	0.005 [0.24583]
Δ(OPENESS)t-1	0.348 [0.85182]	-0.021 [-0.08564]	-0.024 [-1.91560]	-0.001 [-1.04233]	0.019 [0.54776]
Δ(Commo)t-1	-3.641 [-0.49206]	1.754 [0.39052]	-0.003 [-0.01539]	0.055 [3.36804]	0.056 [0.08988]
$\Delta(RER)_{t-1}$	0.115 [0.39799]	0.000 [0.00153]	-0.009 [-0.96770]	-0.002 [-2.43241]	0.035 [1.41664]
Δ((Man_Serv)t-1	-18.324 [-0.60313]	-5.007 [-0.27160]	1.299 [1.39339]	0.019 [0.27704]	2.205 [0.86218]
Δ(Product)t-1	32.382 [0.87400]	5.676 [0.25249]	0.666 [0.58611]	0.076 [0.92239]	-0.364 [-0.11663]
Δ(Inflows)t-1	5.846 [2.14826]	2.401 [1.45409]	-0.016 [-0.19381]	-0.018 [-2.97418]	-0.222 [-0.96718]
C	-0.905 [-0.55703]	0.397 [0.40245]	0.029 [0.58784]	0.010 [2.82502]	0.147 [1.07193]
ECM_Ct-1	-0.164 [-1.14754]	0.042 [0.48507]	0.000 [-0.00444]	-0.002 [-5.91250]	0.009 [0.77427]
ECM_Mt-1	-1.541 [-0.21978]	-1.280 [-0.30093]	0.198 [0.92211]	-0.003 [-0.17246]	-0.054 [-0.09232]

t-statistics are in brackets. ECM_Ct-1 and ECM_Mt-1 are the residuals of the Long-run competitiveness equation and long-run relative manufacturing equation, respectively.

Appendix G: Estimation results when RER is replaced by COMMO –equation (4.3)

RER=f(PRODUCT,COMM,*GOV*, OPEN, INFLOW)

MAN_SERV = F (COMMO, PRODUCT, OPEN, INFLOW,GOV)

Johansen cointegration tests

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	2	3	3
Max-Eig	2	2	2	2	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Long-run relationships

CointegratingEq:	CointEq1	CointEq2
$(RER)_{t-1}$	-1.000.000	0.000000
(Commo)t-1	4.650.759 -101.052 [4.60232]	0.182518 (0.14989) [1.21771]
(Man_Serv)t-1	0.000000	-1.000.000
(GOV)t-1	1.592.157 (0.34849) [4.56872]	-0.024006 (0.00517) [-4.64430]
(OPENESS)t-1	-4.247.109 (0.68556) [-6.19509]	0.052513 (0.01017) [5.16426]
(Product)t-1	-0.915238 -764.294 [-0.01197]	1.238.306 -113.364 [1.09233]
(Inflows)t-1	-1.038.388 -425.211 [-2.44206]	-0.138734 (0.06307) [-2.19969]
C	1.922.805	-3.844.675

Standard errors in ( ) & t-statistics in [ ]

Speed of adjustment

Error Correction	Δ(RER)	Δ(Commo)	Δ(Man_Serv)	Δ(GOV)	Δ(OPENESS)	Δ(Product)	Δ(Inflows)
Long-run competiveness equation	-0.038835	-0.002799	0.000730	-0.224123	0.057172	-0.001643	0.013739
	(0.08708)	(0.00359)	(0.00081)	(0.12063)	(0.07232)	(0.00028)	(0.00951)
	[-0.44595]	[-0.78077]	[0.89868]	[-1.85799]	[0.79058]	[-5.83122]	[1.44519]
Long-run relative manufacturing equation	2.069.808	0.122526	0.028360	-1.113.563	0.820926	-0.064051	0.702042
	-649.994	(0.26761)	(0.06065)	-900.365	-539.774	(0.02103)	(0.70958)
	[3.18435]	[0.45786]	[0.46757]	[-1.23679]	[0.15209]	[-3.04629]	[0.98938]

Δ=1-L is the difference operator where L is the lag operator such that $Lx_t = x_{t-1}$.
t-statistics are in brackets and the p-value for the LR-test on the restrictions is 0.26.
*denotes significance at 5% level

VECM system short-run coefficients

	Δ(RER)		Δ((Man_Serv)	
	Coefficient	t-statistics	Coefficient	t-statistics
$\Delta(RER)_{t-1}$	-0.497371	[-2.37899]	-0.002760	[-1.41476]
Δ(Commo)t-1	7.002.812	[1.33440]	0.043388	[0.88598]
Δ((Man_Serv)t-1	4.470.435	[2.09442]	-0.372724	[-1.87131]
Δ(GOV)t-1	0.474128	[2.74073]	-0.000591	[-0.36601]
Δ(OPENESS)t-1	-0.871656	[-2.93791]	-0.004172	[-1.50676]
Δ(Product)t-1	5.024.515	[0.19518]	-0.138463	[-0.57638]
Δ(Inflows)t-1	1.609.648	[0.76659]	-0.011857	[-0.60512]
C	0.312818	[0.26780]	-0.024684	[-2.26454]
SummaryStatistics				
R-squared	0.676692		0.393168	
Adj. R-squared	0.572772		0.198115	
S.E. equation	6.847.933		0.063902	

Residual multivariate serial correlation analysis: Lagrange Multiplier (LM) Test

Lags	LM-Stat	Prob
1	49.91849	0.4366
2	54.62263	0.2695
3	45.64108	0.6101
4	53.65937	0.3003
5	38.06780	0.8708
6	28.57306	0.9913
7	32.72669	0.9643
8	46.97774	0.5555
9	48.38471	0.4980
10	38.00304	0.8725

Null Hypothesis: no serial correlation at lag order h.Probs from chi-square with 49 df.

Residual multivariate normality tests: Null Hypothesis: residuals are multivariate normal.

Component	Jarque-Bera	df	Prob.
Joint	11.85549	14	0.6179

Orthogonalization is based on Cholesky (Lutkepohl)

VEC Residual Heteroskedasticity Tests: No Cross Terms

Joint test:

Chi-sq	df	Prob.
533.0200	560	0.7880

Chapter 5

Conclusions

In this concluding chapter I will first present an executive summary of my key findings in the section *Overall Conclusion.* Then in the section *Future Development*, I make suggestions for potential future research in the final remarks. Finally, I report on the seminars, congresses, awards and articles that resulted from this thesis.

5.1. Overall Conclusion

This thesis contains three essays that relate, in one way or another, to the evolution of raw material prices: the forces that drive commodity prices on an international scenario, the new role of uncertainty in determining such prices, and the impact of commodity booms in a commodity-dependent economy such as Colombia.

The first essay reports interesting results, evaluating non energy price co-movement and the variables that determine such co-movement in the short term. The study found that after late 2003, not only is there greater synchronization among non-energy commodity prices, but also, notably, a considerable increase in the role of uncertainty as a determinant of commodity price co-movement. These findings are important because they evidence the transformation that is taking place in the commodity market, especially in short term price determination, possibly enhanced by the financialization process. Since late 2003, market uncertainty has played a larger role in explaining non-energy fluctuation than fundamentals such as the real exchange rate and the real interest rate, and this confirms that the commodity market is in transformation. As previously explained in the thesis, since late 2003 there has been an extraordinary increase not only in the investment driven towards the commodities market, but also in the number of participants or financial investors, which is known as financialization. Although this essay does not examine a direct relationship between the financialization of the commodity market and non-energy raw material price formation, it does give evidence which confirms that, at least in a short term context, real prices are behaving more as speculative assets.

Given the increase in the common evolution of non-energy raw material prices after 2004, in the second essay the predictive content of the co-movement either of a large range of commodities, or the co-movement within a specific category of raw material prices is evaluated. The essay reports success in using small scale factor models in forecasting the nominal price of non-energy commodity changes on a monthly basis. Therefore, communalities of commodities in the same category, estimated by the Kalman filter, can be useful for forecasting purposes. Notably, category communalities in oils and protein meals, as well as metals, seem to substantially improve the forecasting performance of the random walk model. In contrast, co-movement in extensive data of commodity prices, estimated through principal components, has poor predictive power over non-energy commodity prices, compared to the small-scale factors. These findings are important since they prove that the co-movement of commodities with similar characteristics has much better predictive power over non-energy commodity prices, than the co-movement of a large range of commodity prices data.

Finally, the last essay tackles the issue of raw material prices from a different angle. This article does not concentrate on analyzing the global determinants of the common patterns of prices as the first article, but evaluates the implications of the evolution of these prices in a small commodity-exporting country such as Colombia. Specifically, the article focuses mainly on evaluating whether, in the long run, resource booms have brought about the following negative implications in the Colombian economy: a real appreciation of local currency, which harms competitiveness, and a decrease of the manufacturing sector related to that of non-tradable goods or services (relative de-industrialization). The results of this paper are important not only because they give solid empirical evidence against the de-industrialization hypothesis due to the negative effects of a resource boom, but also because the results give clues to policymakers on how to prevent future negative effects of commodity price booms, since they show that the major source of pressure on real exchange rate is public spending.

5.2. Future development

The empirical results found in this thesis regarding the importance of market uncertainty in non-energy price determination, provides a solid foundation for beginning a line of research attempting to explain the new role of market uncertainty and expectations in the commodity markets at all levels. I will give some key issues of a research agenda derived from the thesis. First, an avenue for future research relates to the use of high frequency data to analyze the influence of macroeconomic and financial variables, especially market uncertainty, as well as a stock market index in non-energy commodity prices. As raw material prices may have characteristics of a financial asset, they may react more quickly to all kinds of information. Therefore, it would be interesting to know the extent and magnitude of shocks in market uncertainty, and in the stock index over non energy commodity prices on a daily basis. Second, I identify a lack of theoretical research aimed at explaining the empirical relationship between uncertainty and the commodity market that documented in the thesis. Specifically, there is a need for a unifying theory of short term price formation that takes into account the new importance of co-movement between different commodities (and between commodities and other assets) and uncertainty, as well as traditional factors such as macroeconomic and commodity-specific fundamentals. Third, as the second essay evaluates the predictive content of co-movement in non-energy commodity prices, the logical extension would be to assess the role of uncertainty in commodity markets as a possible source of predictability. A fourth issue of interest is to evaluate the volatility spillovers between the uncertainty measure, the equity market and the commodity market. In the first essay, the first moments or return linkages among variables are evaluated, however, volatility spillover effects are also important for analyzing market integrations. More importantly, although I evaluate the long term effects of a resource boom in the real exchange rate and the relative manufacturing output, the role of volatility spillovers between the uncertainty measure, the commodity market, and finally the output growth in commodity-dependent countries have not been researched. Commodity prices are known as having high volatility related to manufacturing, which prompts the following questions: does financialization in the commodity market increase such volatility? And how would that impact terms of trade and the economy in general in a commodity-dependent country?

5.3. Dissemination of results

The different essays that constitute the central body of this dissertation have been presented at various international and national meetings. In what follows, I provide a list of the congresses and seminars where the essays have been presented.

Congresses

- Annual Meeting of the Association of Southern European Economic Theorists, ASSET 2013.

  November, 7th, 8th and 9th 2013 in Bilbao, Spain.

  "What drives co-movement in commodity prices?".

- 20th Annual Conference of the European Association of Environmental and Resource Economists, EAERE.

  June, from the 26th to the 29th 2013 in Toulouse, France.

  I presented "Long-term links between raw materials prices, real exchange rate and relative de-industrialization in a commodity dependent economy. Empirical evidence of `Dutch disease' in Colombia".

- XVI Encuentro de Economía Aplicada, EEA.

  June, 6th and 7th 2013 in Granada, Spain.

  I presented "Dutch Disease in Colombia. Empirical evidence".

- 10th Eurasia Business and Economics Society conference, EBES.

  May, 23th, 24th and 25th 2013 in Istanbul, Turkey.

  I presented "What drives co-movement in commodity prices?".

- 6th CSDA International Conference on Computational and Financial Econometrics.

  December, 1th , 2th and 3th 2012 in Oviedo, Spain.

  "Evidence of excess of co-movement in commodity prices at high frequencies"

Seminars

- Seminario de investigación. Departamento de Análisis Económico: Economía Cuantitativa. Universidad Autónoma de Madrid.

  December, 5th 2013.

  "The dynamics of co-movements and the role of uncertainty as a driver of non-energy commodity prices".
- Seminario del Máster de Análisis Económico Aplicado. Universidad de Alcalá.

  November, 29th 2013 in Alcala, Spain.

  "What moves non-energy raw material prices?".
- Seminario de Investigación de Economía. Pontificia Universidad Javeriana de Cali, Colombia.

  July, 24th 2013 in Cali, Colombia

  "Evidencia empírica de enfermedad Holandesa en Colombia".
- Seminario de investigación. Departamento de Análisis Económico: Economía Cuantitativa. Universidad Autónoma de Madrid.

  April, 2th 2014.

  Thesis seminar

Working papers

- Poncela, P., Senra, E. and Sierra, L. (2012) Is the boost in oil prices affecting the appreciation of real exchange rate?: empirical evidence of `Dutch Disease´ in Colombia, Documentos de Trabajo, No. 694, Fundación de las Cajas de Ahorros, FUNCAS, Madrid.
- Poncela, P., Senra, E. and Sierra, L. (2013) The dynamics of co-movement and the role of uncertainty as a driver of non-energy commodity prices, Documento de Trabajo No. 733, Fundación de las Cajas de Ahorros, FUNCAS, Madrid.

Awards

- Premio Estímulo a la Investigación, FUNCAS, 2013.
- Grant assignment of 1.500 euros for participation in the EAERE 20th Annual Conference.

Conclusiones

En el presente capítulo se suministra un resumen de las principales conclusiones en la sección Conclusiones Generales. Posteriormente, en la sección Desarrollos Futuros, se describen las líneas de investigaciones futuras derivadas de los trabajos contenidos en esta tesis. Por último, se reportan los seminarios, congresos y artículos de investigación derivados de la tesis.

Conclusiones Generales

La tesis contiene tres capítulos que se relacionan con la evolución de los precios de las materias primas: las fuerzas que impulsan los precios de los productos básicos en un escenario internacional, el nuevo papel de la incertidumbre en la determinación de dichos precios, el contenido predictivo del movimiento conjunto en los precios, y el impacto de períodos de auge en los precios de las materias primas en una economía pequeña y dependiente de estos recursos, como es el caso de Colombia.

El primer artículo reporta resultados interesantes cuando evalúa el movimiento conjunto en los precios de las materias primas no energéticas y las variables que determinan tal movimiento conjunto en el corto plazo. El estudio encontró que a partir de finales del año 2003, no sólo hay una mayor sincronización entre los precios de las materias primas no energéticas, sino que también y sobre todo, la importancia de la incertidumbre como factor determinante del movimiento conjunto aumentó considerablemente en este periodo. Estos hallazgos son importantes porque evidencian la transformación que está teniendo lugar en el mercado de materias primas, especialmente en la determinación de los precios a corto plazo, tal vez reforzada por el proceso de financialización. El hecho de que a partir del año 2003 la incertidumbre de mercado ha desempeñado un papel más importante en la explicación de las fluctuaciones en los precios, que variables fundamentales como el tipo de cambio real y la tasa de interés real, confirma el hecho de que el mercado de las materias primas está en transformación. Como se explica en la tesis, la financialización en el mercado de materias primas, a partir de finales de 2003, trajo consigo un aumento extraordinario de la inversión impulsada por el mercado de materias primas y del número de participantes o de los inversores financieros. Aunque este artículo no prueba la relación directa entre la financialización en el mercado de materias primas y la formación de los precios de materias primas no energéticas, sí provee evidencia empírica a favor de que, al menos en un contexto de corto plazo, los precios reales se asemejan a activos especulativos.

Dado el aumento en el nivel de sincronización de los precios de las materias primas a partir del año 2004, en el segundo artículo se evalúa el contenido predictivo del co-movimiento, ya sea teniendo en cuenta una gran cantidad de series de precios de materias primas, o el movimiento conjunto existente dentro de cada una de las categorías de materias primas no energéticas. En el artículo se reportan resultados exitosos en cuanto a la capacidad predictiva de los modelos factoriales dinámicos a pequeña escala, los cuales tienen en cuenta las comunalidades de las materias primas dentro de una categoría. Por lo tanto, el movimiento conjunto de productos dentro de la misma categoría, que se estima mediante el filtro de Kalman, puede ser útil para predecir la inflación de las materias primas no energéticas a un horizonte de un mes. Cabe destacar que para las categorías aceites y harinas proteicas, así como los metales, la capacidad predictiva de los modelos factoriales dinámicos a pequeña escala es ampliamente superior frente a los pronósticos generados por una caminata aleatoria. Por el contrario, movimiento conjunto de una gran cantidad de series de inflaciones en precios de las materias primas que se estima a través de componentes principales, tiene escaso poder predictivo sobre los precios de las materias primas no energéticas, en comparación con los modelos factoriales de pequeña escala. Estos hallazgos son importantes ya que demuestran que el movimiento conjunto de materias primas con características similares tiene mejor poder predictivo sobre los precios de los productos básicos no energéticos frente al movimiento conjunto de una amplia gama de datos de precios de los productos básicos.

Finalmente, en el último artículo se aborda el tema de los precios de las materias primas desde un ángulo diferente. Este artículo no se centra en el análisis de los determinantes globales de los patrones comunes de precios como lo hace el primero, sino que evalúa las implicaciones de la evolución de estos precios en un país pequeño exportador de materias primas. En concreto, el artículo se centra en evaluar si en el largo plazo booms en los recursos exportados han dado lugar a las siguientes consecuencias negativas para la economía colombiana: una apreciación real de la moneda local, lo que perjudica la competitividad, y una disminución en la producción manufacturera en relación a la de bienes o servicios no comercializables (desindustrialización relativa).

Los resultados de este trabajo son importantes no sólo porque dan una sólida evidencia empírica en contra de la hipótesis de la desindustrialización a causa de los efectos negativos de un auge de recursos, sino también porque los resultados dan herramientas a los responsables políticos sobre la manera de prevenir futuros efectos negativos de booms en los productos básicos exportados, ya que muestra que la principal fuente de presión sobre el tipo de cambio real es el gasto público.

Desarrollos futuros

Los resultados empíricos encontrados en esta tesis sobre la importancia de la incertidumbre del mercado en la determinación de los precios de materias primas no energéticas, proporciona una base sólida para iniciar una línea de investigación que se proponga explicar el nuevo papel de la incertidumbre del mercado en los mercados de materias primas a todos los niveles. A continuación se presentan algunos temas clave de una posible agenda de investigación derivada de la tesis. Una primera línea de investigación futura tiene que ver con el uso de datos de alta frecuencia para analizar la influencia de las variables macroeconómicas y financieras, especialmente la incertidumbre de mercado, en los precios de las materias primas no energéticas. Debido a que los precios de las materias primas pueden tener características de un activo financiero es normal que reaccionen más rápidamente a todo tipo de información. Por lo tanto, resulta interesante conocer la longitud y el tamaño de los choques en la incertidumbre del mercado sobre los precios de las materias primas no energéticas a una frecuencia diaria. En segundo lugar, se identificó un vacío teórico en cuanto a modelos que ayuden a explicar la relación empírica entre la incertidumbre y los precios de las materias primas no energéticas, la cual se documenta en la tesis. Para precisar, existe necesidad de una teoría unificadora sobre la formación de precios a corto plazo que tenga en cuenta la nueva importancia del movimiento conjunto entre diferentes materias primas (y entre las materias primas y otros activos) y la incertidumbre, así como los factores tradicionales, entre ellos variables macroeconómicas y factores específicos, propios de cada mercado.

En tercer lugar, dado que el segundo artículo evalúa el contenido predictivo del movimiento conjunto en los precios de las materias primas no energéticas, la extensión lógica sería la de evaluar el papel de la incertidumbre en los mercados de productos básicos como una posible fuente de previsibilidad. Un cuarto tema de interés está relacionado con la evaluación de los efectos o conexiones entre la medida de la incertidumbre y la volatilidad del mercado de acciones y el mercado de productos básicos. En el primer artículo se analizaron los primeros momentos o los vínculos entre los retornos de las variables, sin embargo, los efectos de derrame de la volatilidad, *spillover effects,* también son importantes para el análisis de las integraciones de mercado.

Más importante, aunque evalué los efectos en el largo plazo de auges en las materias primas exportadas sobre el tipo de cambio real y de la producción manufacturera relativa, la importancia de los efectos contagio, *spillover effects,* entre la medida de incertidumbre, la volatilidad en el mercado de materias primas, y finalmente, la volatilidad en el crecimiento de la producción en los países dependientes de productos básicos, no se ha investigado hasta el momento. Los precios de las materias primas son conocidos por tener una alta volatilidad debido a su proceso de producción o extracción, lo cual anima a las siguientes preguntas: ¿la financialización en el mercado de materias primas ha aumentado tal volatilidad? ¿Cómo afecta la financialización en el mercado de materias primas los términos de intercambio y la economía en general de un país dependiente de los productos básicos?.

Difusión de Resultados

Los capítulos que conforman el cuerpo central de la tesis han sido presentados en diferentes congresos a nivel nacional e internacional. A continuación se provee una lista de los seminarios y congresos donde estos han sido presentados.

Ponencias en congresos

- Annual Meeting of the Association of Southern European Economic Theorists, ASSET 2013.
  7 al 9 de noviembre de 2013 en Bilbao, España.
  "¿What drives co-movement in commodity prices?"
- 20th Annual Conference of the European Association of Environmental and Resource Economists, EAERE.
  26 al 29 de junio de 2013 en Toulouse, Francia.
  "Long-term links between raw materials prices, real exchange rate and relative de-industrialization in a commodity dependent economy. Empirical evidence of `Dutch disease' in Colombia".
- XVI Encuentro de Economía Aplicada, EEA.

6 y 7 de Junio de 2013 en Granada, España.

"Dutch Disease in Colombia. Empirical evidence".

- 10th Eurasia Business and Economics Society conference, EBES.

  23 al 25 de mayo de 2013 en Estambul, Turquía.

  "What drives co-movement in commodity prices?".

- 6th CSDA International Conference on Computational and Financial Econometrics.

  1al 3 de diciembre de 2012 en Oviedo, España.

  "Evidence of excess of co-movement in commodity prices at high frequencies".

Presentaciones en seminarios de investigación

- Seminario de investigación. Departamento de Análisis Económico: Economía Cuantitativa. Universidad Autónoma de Madrid.

  5 de diciembre de 2013 en Madrid, España.

  "The dynamics of co-movements and the role of uncertainty as a driver of non-energy commodity prices".

- Seminario del Máster de Análisis Económico Aplicado. Universidad de Alcalá.

  29 de noviembre de 2013 en Alcalá, España.

  "What moves non-energy raw material prices?".

- Seminario de Investigación de Economía. Pontificia Universidad Javeriana de Cali, Colombia.

  24 de Julio de 2013 en Cali, Colombia.

“Evidencia empírica de enfermedad Holandesa en Colombia”.

- Seminario de investigación. Departamento de Análisis Económico: Economía Cuantitativa. Universidad Autónoma de Madrid.
  2 de abril de 2014.

Documentos de trabajo

- Poncela, P., Senra, E. and Sierra, L. (2013) The dynamics of co-movement and the role of uncertainty as a driver of non-energy commodity prices, Documento de Trabajo No. 733, Fundación de las Cajas de Ahorros, FUNCAS, Madrid.
- Poncela, P., Senra, E. and Sierra, L. (2012) Is the boost in oil prices affecting the appreciation of real exchange rate?: empirical evidence of `Dutch Disease´ in Colombia, Documentos de Trabajo, No. 694, Fundación de las Cajas de Ahorros, FUNCAS, Madrid.

Reconocimientos

- Premio Estímulo a la Investigación, FUNCAS, 2013.
- Beca de 1.500 euros para participar en la conferencia anual de EAERE en 2013.