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The rationale of commodity currencies: Speculation or sound macroeconomic basis?

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Résumé

Ce mémoire cherche à identifier le fondement économique des monnaies liées aux matières premières que sont les dollars australien, canadien et néo-zélandais, en examinant deux hypothèses. La première est que l'impact du cours des matières premières locales sur le taux de change réel résulte principalement d'une demande spéculative ou d'anticipations du taux de change futur. La seconde est que cet impact dépend de l'effet du cours des matières premières sur des variables macroéconomiques fondamentales (telles le niveau des prix à la consommation, le PIB réel ou les taux d'intérêts réels) et de la persistance des variations du taux de change suite à un choc dans le prix des matières premières. En utilisant un modèle SVECM (Structural Vector Error Correction Model) pour chacun des trois pays considérés, nos résultats suggèrent qu'au moment d'une hausse non anticipée du prix des matières premières, l'appréciation réelle du taux de change dépend presque entièrement de sa composante spéculative. Cependant, suite à cette hausse initiale, l'effet des fondamentaux macroéconomiques et de la persistance des mouvements de taux de change domine, rendant ainsi la composante spéculative négligeable.

Mots clés : Monnaies liées aux matières premières, Economies liées aux matières premières, Taux de change, Structural Vector Error Correction Model (SVECM), Vector AutoRegressive (VAR).

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Avant-propos

Le chapitre 4 de ce mémoire comprend l'article "The rationale of commodity currencies: Speculation or sound macroeconomic basis?" rédigé en anglais. L'intégralité des autres chapitres est rédigée en français.

Chapitre 1 : introduction

Le boom des ressources naturelles qui s'est déroulé de 2000 à 2008 a accru l'intérêt des chercheurs pour les matières premières, tant d'un point de vue économique que financier. Un sujet devint particulièrement prisé dans la littérature : le lien entre prix des matières premières et taux de change des pays exportateurs de ressources naturelles. Parmi ces pays se trouvent trois économies développées, l'Australie, le Canada et la Nouvelle-Zélande. Au cours des années 2000, lorsqu'à la fois le prix des matières premières et le taux de change de ces pays s'établissaient à des niveaux records, il n'était pas inhabituel d'entendre des dirigeants économiques ou politiques déclarer que la monnaie de leur pays était surévaluée. Le taux de change est en effet un important déterminant à court terme de la compétitivité des entreprises nationales. Ces observations soulèvent une question : jusqu'à quel point ce lien entre prix des matières premières et taux de change est-il économiquement justifié ? La réponse à cette question a de profondes implications en termes de gestion des taux de change. Si les taux de changes de l'Australie, du Canada et de la Nouvelle-Zélande s'expliquent par l'effet des matières premières sur des variables macroéconomiques fondamentales, alors l'on peut considérer la valeur de leur monnaie comme justifiée d'un point de vue économique.[1] Des interventions sur le marché des changes seraient alors sans fondement. Dans le cas contraire, c'est-à-dire si les matières premières n'ont pas d'effet sur les fondamentaux économiques mais qu'elles influencent tout de même les taux de change, on peut penser que la variation de ces taux est en partie due à de la spéculation. Des déclarations publiques ou des interventions visant à ramener les devises considérées vers leur juste valeur seraient alors justifiables.

Le but de ce mémoire est de mesurer l'importance de deux forces qui influencent le taux de change des monnaies liées aux matières premières. D'abord, nous isolons une demande

[1] Dans ce mémoire les termes de variables macroéconomiques fondamentales ou plus simplement de « fondamentaux » englobent les prix à la consommation, le Produit Intérieur Brut (PIB) réel et les taux d'intérêts réels.

spéculative, c'est-à-dire des anticipations de taux de change futur ne se basant que sur le mouvement du prix des matières premières. Ensuite, nous considérons une demande fondamentale, c'est-à-dire résultant de l'effet des matières premières sur les fondamentaux économiques.

Les premiers articles consacrés à l'interaction entre taux de change et matières premières remontent à la fin des années 1990.[2] Le concept de monnaie liée aux matières premières a été introduit par Chen et Rogoff (2003), qui montrent un lien significatif entre taux de change réel de l'Australie, du Canada et de la Nouvelle-Zélande, et prix réel de leurs exports de matières premières. Des études de ce type ont ensuite été réalisées pour des pays en développement, aux économies souvent dépendantes d'un faible nombre de ressources. Leurs résultats quant à l'impact des matières premières sur les économies locales et les taux de change sont logiquement très concluants.[3]

Cependant, dans la littérature existante, la justification du lien entre matières premières et taux de change est souvent rapidement abordée et se limite à l'explication du rôle joué par les exports nets sur le taux de change : les matières premières produites nationalement étant en majeure partie exportées, une hausse de leur cours améliore la balance commerciale, ce qui augmente la demande relative pour la monnaie nationale qui s'apprécie en conséquence.[4] A notre connaissance, la littérature ne comprend pas d'autres justifications théoriques que les exports pour expliquer la validité du concept de monnaie liée aux matières premières. Par conséquent, ce mémoire étudie deux autres canaux de transmission entre cours des matières premières et taux de change : la spéculation et certaines variables macroéconomiques fondamentales. Ces deux canaux seront identifiés en analysant la réponse du taux de change

[2] Cf. Amano et Van Norden (1998), article liant le dollar US, le yen japonais et le deutschemark allemand au prix du pétrole.

[3] Cf. Bodart, Candelon et Carpentier (2011).

[4] Voir par exemple Chen (2004), page 4.

réel à un choc dans le prix des matières premières nationales. Cette réponse est décomposée en deux types d'effets. D'abord en un effet direct et spéculatif qui ne s'explique que par la variation de prix de ces matières premières. Ensuite, en un effet indirect et fondamental résultant de l'impact des matières premières sur les variables fondamentales inclues dans le modèle.

La réponse du taux de change réel à un choc dans le prix des matières premières locales est calculée en utilisant un modèle SVECM (Structural Vector Error Correction Model), introduit par King et al. (1991). Ce type de modèle permet à chaque variable considérée d'influencer toutes les autres, avec quelques restrictions concernant leurs interactions simultanées. Le modèle inclut un terme de correction d'erreur, plusieurs de nos séries macroéconomiques étant cointégrées. Cinq variables sont incluses dans le SVECM pour chaque pays : le prix des matières premières nationales, le niveau général des prix à la consommation, les taux d'intérêts réels, le PIB réel et enfin le taux de change réel vis-à-vis du dollar américain. Les trois pays choisis sont étudiés avec des données trimestrielles jusqu'à la fin 2012 mais durant des périodes différentes, ayant laissé fluctuer librement leurs monnaies à des dates différentes : l'Australie en 1983, le Canada en 1970 et la Nouvelle-Zélande en 1985. Enfin, des tests de robustesse sont effectués pour le Canada avec des données mensuelles.

La séparation de la réponse du taux de change réel suite à un choc dans le cours des matières premières locales donne des résultats intuitifs et similaires dans nos différents échantillons. Au moment du choc, l'appréciation réelle significative que l'on constate est presque entièrement expliquée par l'effet direct et spéculatif du choc, qui semble refléter des anticipations quant aux valeurs futures du taux de change. Un trimestre après le choc, l'effet indirect et fondamental devient dominant, ce qui est cohérant avec une influence retardée des matières premières sur les fondamentaux économiques. Les deux effets sont moins prononcés à partir de deux trimestres après le choc. Du fait de la faible persistance de cet effet spéculatif, on peut estimer que le lien entre matières premières et monnaies liées aux matières premières résulte principalement d'un effet fondamental des ressources naturelles sur les économies considérées.

Cette étude contient également deux autres types de résultats. La décomposition de l'effet indirect et fondamental en ses quatre composantes (prix à la consommation, PIB réel, taux d'intérêts réels et valeurs passées du taux de change réel) donne des résultats similaires en Australie et au Canada. Dans ces deux pays, cet effet est dominé à chaque période après le choc par les réponses passées du taux de change réel au choc initial. Cela traduit une forte persistance des mouvements de taux de change suite à un choc dans le prix des matières premières. Dans le cas de la Nouvelle-Zélande, l'effet fondamental s'explique principalement par deux composantes : les réponses passées du taux de change et les prix à la consommation. Ces derniers représentent donc un canal de transmission valide entre cours des matières premières et taux de change réel : la hausse des prix à la consommation consécutive à un choc dans le prix des matières premières contribue elle aussi à l'appréciation réelle du dollar néo-zélandais.

Enfin, l'effet significatif qu'a le cours des matières premières sur les fondamentaux économiques des pays considérés, suggéré par la littérature, est confirmé. Le taux de change réel, les prix à la consommation et les taux d'intérêts réels sont influencés par un choc de prix des matières premières à un niveau de confiance de 95% dans les trois pays sélectionnés. Le PIB réel n'est significativement affecté qu'au Canada.

Ce mémoire est organisé de la manière suivante. Le chapitre 2 est consacré à la revue de littérature. Le chapitre 3 détaille la méthode économétrique employée. Le chapitre 4 contient l'article "The rationale of commodity currencies: Speculation or sound macroeconomic basis?". Le chapitre 5 résume les résultats de cet article et conclut l'ensemble du présent mémoire.

Chapitre 2 : revue de littérature

La littérature portant sur les taux de change a historiquement tenté d'expliquer les mouvements de devises à l'aide de modèles économétriques incluant des variables macroéconomiques fondamentales comme les exports, le PIB, l'inflation, les taux d'intérêts ou les exports avec des résultats en général peu probants. L'absence de lien significatif entre fondamentaux et taux de change a ainsi été nommé l'énigme de la déconnexion des taux de change ("exchange rate disconnect puzzle") par Obstfeld et Rogoff (2000).

Cependant, ces résultats ne remettent pas en cause la logique macroéconomique qui mène à penser que les fondamentaux sont de valides déterminants des taux de change, comme le notent Sarno et Valente (2008). En outre, on peut penser que les monnaies liées aux matières premières, du fait de leur dépendance envers les ressources naturelles, ont des variations moins difficiles à expliquer, comme le montre Chen (2004).

Par conséquent cette revue de littérature portera principalement sur deux types d'articles. D'abord, ceux dédiés aux monnaies liées aux matières premières, qui sont la base de la problématique de ce mémoire et la raison pour laquelle le groupe de pays ACNZ (Australie, Canada et Nouvelle-Zélande) a été choisi. Ensuite, des articles étudiant les liens entre matières premières et fondamentaux économiques seront abordés. L'utilisation du terme " significatif " renvoie généralement à un niveau de confiance de 95%.

2.1. La littérature portant sur les monnaies liées aux matières premières

Comment une monnaie liée aux matières premières est-elle définie ? Le terme a été utilisé en premier dans une étude de Chen et Rogoff datant de 2003, étendue en 2012 à d'autres pays que le groupe ACNZ. Dans ces articles, les auteurs montrent qu'il existe un lien significatif entre prix réel en dollar US des matières premières exportées et taux de change réel vis-à-vis des Etats-Unis pour les pays considérés, soit l'Australie, le Canada, la Nouvelle-Zélande, l'Afrique du Sud et le Chili. Cette relation est établie à l'aide de régressions par Moindres Carrés Ordinaires (MCO), sur une période presque identique à celle choisie pour ce mémoire.[5] Afin de renforcer la robustesse de ces résultats, les auteurs utilisent différentes mesures du taux de change réel, vis-à-vis de la livre britannique et du yen japonais en plus du dollar américain. Ces mesures alternatives n'affectent pas la validité des résultats. Cependant, la justification théorique de l'existence des monnaies liées aux matières premières se limite à rappeler la part importante que constituent les matières premières dans les exports des pays étudiés, sans inclure cette variable dans les régressions de l'article. Le rôle d'autres variables macroéconomiques ou de la spéculation n'est pas étudié, ce qui est l'objet du présent mémoire.

Suivant l'exemple de Chen et Rogoff (2003), la littérature sur les monnaies liées aux matières premières est désormais étendue et possède des résultats généralement concluants lorsqu'elle porte sur les pays ACNZ. [6] Ces articles portent le plus souvent sur des taux de changes réels, bien que Chen (2004) ait étendu cette relation aux taux de changes nominaux des pays ACNZ. Dans son article, l'auteure compare deux types de modèles destinés à expliquer les variations de taux de change. L'un incorpore un indice de cours des matières premières, l'autre non, mais les deux modèles incluent des variables fondamentales (niveaux des prix à la consommation, PIB réel, taux d'intérêts et masse monétaire). Ces variables sont exprimées relativement au pays concerné, l'étude s'intéressant au taux de change nominal vis-à-vis du dollar US, du yen japonais et de la livre britannique. Les résultats montrent que les modèles incorporant un indice de matières premières expliquent significativement mieux les variations de taux de change nominaux.

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[5] Si l'on considère l'extension de l'article datant de 2012.

[6] Les articles seulement basés sur la Nouvelle-Zélande sont plus rares. On peut cependant citer une étude du dollar australien de Hatzinikolaou et Polasek (2005), qui estime à l'aide d'un VECM une élasticité du taux de change nominal australien pondéré par les échanges relativement aux matières premières produites intérieurement de 0,939.

2.2. La dynamique entre prix des matières premières, fondamentaux macroéconomiques et taux de change

2.2.1. Articles utilisant les MCO

De nombreux articles ont étudié le lien entre matières premières et fondamentaux macroéconomiques des pays ACNZ à l'aide de régressions par MCO. Du fait de leur relative simplicité, ces modèles se concentrent habituellement sur un type de relation, le plus souvent entre prix des ressources naturelles et inflation. Les résultats concernant le lien entre cours des matières premières et inflation sont souvent significatifs à un niveau de confiance de 95% ou 99% dans les pays ACNZ.

Bloch et al. (2006) étudient ainsi l'effet du prix mondial des matières premières, mesuré par l'indice des principales matières premières du FMI en dollars US ("IMF Primary Commodity Prices Index"), sur l'inflation et les taux de change nominaux de l'Australie et du Canada, respectivement depuis 1960 et 1973. Cette étude confirme les résultats de Chen (2004), en constatant une appréciation nominale de la devise nationale suite à une hausse du prix des matières premières libellé en dollars US. L'inflation des deux pays apparait en outre positivement et significativement liée au prix mondial des matières premières. Les auteurs utilisent à la fois des modèles MCO et AutoRegressifs (AR), ces derniers étant plus appropriés aux données étudiées.

Plus récemment, une étude exhaustive de l'effet du cours des matières premières sur l'inflation des pays les plus industrialisés, comprenant les pays ACNZ, a été réalisée par Cheung (2009). L'auteure démontre que l'inclusion du cours des matières premières améliore significativement les prévisions d'inflation à horizon d'un et de deux trimestres. Les résultats de l'article sont robustes à de nombreux changements de spécifications. Le cours des matières premières est mesuré de trois manières différentes : en utilisant l'indice de prix des principales matières premières du FMI libellé en dollar US, en convertissant cet indice en termes locaux à l'aide du taux de change réel du pays considéré vis-à-vis des Etats-Unis, et enfin en désagrégeant l'indice à l'aide d'une analyse en composantes principales. Plusieurs périodes sont considérées, pré ou post adoption du ciblage d'inflation, et les résultats sont évalués avec deux mesures de l'inflation, sous-jacente et totale.

Ces conclusions sont corroborées par Hassan et Salim (2011) dans le cas de l'Australie, qui montrent que l'inflation du pays est causée au sens de Granger par le prix des matières premières, à horizon de quatre mois, et que les deux séries sont cointégrées, c'est-à-dire liée à long terme, en utilisant un échantillon de données mensuelles de 1982 à 2007.

La littérature existante qui est basée sur des régressions MCO suggère donc qu'une relation très significative est attendue entre cours des matières premières et inflation pour les pays ACNZ. Ce type de modèle ne s'est en revanche que peu porté sur l'influence des ressources naturelles sur le PIB et les taux d'intérêts. Cela est cohérent car ces variables fondamentales (PIB, inflation, taux d'intérêts) sont liées et que leurs interactions mutuelles doivent être prises en compte, ce qui est l'objet du prochain type de modèle économétrique considéré.

2.2.2. Articles utilisant des modèles VAR ou VECM

A notre connaissance, des modèles économétriques récents comme les SVECM n'ont pas été appliqués à une étude du groupe ACNZ, mais plutôt à l'étude de pays développés en général.

Dans une étude de 2007, Bloch et al. étudient la dynamique entre prix des ressources naturelles (mesuré par l'indice des principales matières premières du FMI converti en monnaie nationale), production industrielle, prix des produits finis et salaires industriels. Trois pays sont étudiés de 1957 à 2001 avec des données trimestrielles : les Etats-Unis, le Japon et le

Royaume-Uni. Les résultats obtenus montrent que le cours des matières premières affecte positivement le prix des produits finis au Japon et aux Etats-Unis, mais a un impact moins significatif aux Royaume-Uni. Les auteurs utilisent de multiples modèles économétriques : MCO, AR en incluant des variables instrumentales et enfin un VECM. Les conclusions du VECM sont similaires à celles des autres modèles mais le terme de correction d'erreur est significatif. En d'autres termes, ce type de modèle correspond mieux aux données étudiées et conforte notre choix économétrique pour le présent mémoire.

Un modèle similaire à celui choisi pour ce mémoire a été utilisé en 2008 par Cologni et Manera. Les auteurs étudient trimestriellement les variables suivantes de 1980 à 2003 : le prix du pétrole en dollars US, le PIB réel, les taux d'intérêts américains à court terme, l'inflation, l'agrégat monétaire M1 ou son équivalent et les taux de change mesurés en faisant le rapport du taux de change local vis-à-vis des droits de tirage spéciaux (DTS) du FMI sur le taux de change américain vis-à-vis de ces DTS.

Ce modèle est utilisé pour étudier l'effet des prix du pétrole sur les économies du G-7 de 1980 à 2003. Cet effet est analysé à court terme, à travers des réponses d'impact, et à long terme grâce à des relations de cointégration. Comme certains des articles dédiés à l'effet des matières premières sur l'inflation mentionnés précédemment le suggèrent, [7] une relation significative est établie entre prix du pétrole et inflation dans tous les pays à l'exception du Japon et du Royaume-Uni. Cela alors que le G-7 n'inclue qu'une économie possédant d'importantes ressources naturelles, le Canada. Les cours du pétrole influencent la production intérieure dans trois pays : négativement en Allemagne et au Royaume-Uni mais positivement au Canada. Le fait que le Canada est à la fois une inflation et un PIB sensible au cours du pétrole laisse présager de résultats robustes dans notre étude du groupe ACNZ. Cependant, aucune

[7] Par exemple Bloch et al. (2006) et Cheung (2009).

corrélation n'est établie entre prix du pétrole, taux d'intérêts ou taux de change, quel que soit le pays étudié, bien que la mesure de taux de change retenue par les auteurs soit inhabituelle.

Cet article utilise le même modèle économétrique que le présent mémoire, un SVECM. Les avantages de ce modèle sont doubles. D'abord il est une extension des modèles SVAR et permet à chaque variable incluse d'influencer toutes les autres à travers ses valeurs passées et contemporaines, bien que ces effets contemporains doivent faire l'objet de restrictions. Ce type de modèle prend ensuite en compte explicitement les relations de cointegration qui peuvent exister entre plusieurs variables, ce qui est fréquent si l'on considère des variables macroéconomiques à long terme.

Néanmoins, si cet article utilise le même modèle que la présente étude, tous deux ont des objectifs différents. D'abord nous nous intéressons à l'effet du prix des principales matières premières produites intérieurement et non à une ressource en particulier comme le pétrole. Les taux de change sont de plus l'élément central de ce mémoire et seront donc mesurés par des taux de marché, et non par des valeurs fixées par le FMI comme le taux des DTS. Une différence majeure provient en outre de l'utilisation des réponses du taux de change suite à un choc dans le prix des matières premières. En plus d'analyses standard de ces réponses, nous décomposons l'effet de ce choc sur le taux de change en deux effets, un effet spéculatif qui ne dépend que de la variation du cours des matières premières, et un effet fondamental qui dépend des autres variables inclues dans le modèle.

Enfin, un article récent de Le et Chang (2011) contredit certains des résultats mentionnés précédemment. Leur étude est consacrée au Japon et particulièrement aux effets des cours réels de l'or et du pétrole (leur prix en dollars est converti en yens puis déflaté par l'inflation locale) sur des variables économiques et financières comme le prix réel des actions locales ainsi que les taux d'intérêts nominaux et le taux de change nominal vis-à-vis du dollar US. Un lien à court terme est établi entre taux d'intérêts et prix réel de l'or, ce qui suggère que certaines matières premières peuvent influencer les taux d'intérêts y compris en dehors de pays riches en ressources naturelles. L'hypothèse d'une influence des ressources naturelles sur les taux d'intérêts réels locaux est testée par notre modèle économétrique pour chaque pays du groupe ACNZ. Les auteurs utilisent un VECM avec une fréquence de données mensuelle, de 1986 à 2011. Cette différence de fréquence explique peut-être le lien à long terme existant entre taux d'intérêts et prix du pétrole au Japon selon les auteurs, alors que d'après Cologni et Manera (2008) ces deux variables ne sont pas liées. Le terme de correction d'erreur du VECM est significatif, ce qui conforte notre choix de modèle.

Chapitre 3 : méthode économétrique

Ce chapitre inclut une description détaillée du type de modèle utilisé dans ce mémoire, ainsi qu'une explication de la manière dont l'impact du prix des matières premières sur le taux de change réel est décomposé et analysé.

3.1. Modèle économétrique

3.1.1. Modèle structurel

Le modèle structurel retenu pour étudier chaque pays est un SVECM, qui prend la forme suivante :

$$\Theta\Delta X_t = \delta + \Pi X_{t-1} + \Phi_1 \Delta X_{t-1} + \Phi_2 \Delta X_{t-2} + \ldots + \Phi_p \Delta X_{t-p} + U_t. \quad (1)$$

Les trois pays choisis sont étudiés durant différentes périodes, car ils n'ont pas adopté un système de taux de change flottant à la même date. Cinq variables sont inclues dans le vecteur X_t : le log de la mesure du prix des matières premières nationales, P_t, le log du niveau des prix à la consommation, I_t, le log du PIB réel, Y_t, les taux d'intérêt réels à cinq ans sur les obligations gouvernementales, R_t ,[8] et enfin le log du taux de change réel par rapport au dollar US, Q_t. Le vecteur X_t est alors défini comme : $X_t = (P_t \quad I_t \quad Y_t \quad R_t \quad Q_t)'$.

Le vecteur ΔX_t contient quant à lui la première différence de ces cinq variables, celles-ci contenant toutes des racines unitaires. La matrice Θ inclut certaines interactions contemporaines entre les variables du modèle, tandis que le vecteur δ inclut une constante par équation structurelle. En effet, comme nous le verrons dans la partie 3.1.3., on ne peut permettre à chaque variable d'être contemporainement influencée par toutes les autres. Les

[8] Pour être exact, les taux sur les obligations gouvernementales d'une maturité de trois à cinq ans pour le Canada.

relations de cointégrations entre plusieurs variables sont prises en compte par le vecteur Π. Enfin, les matrices Φ_i reflètent les interactions entre valeurs courantes et passées des variables.

L'élément crucial d'un modèle structurel réside dans la structure de ses erreurs. Si l'on dénote par $U_t = (U_{Pt} \quad U_{It} \quad U_{Yt} \quad U_{Rt} \quad U_{Qt})$ le vecteur d'erreurs structurelles associées à X_t, ces erreurs structurelles sont orthogonales : $E[U_t U_t'] = I$. En d'autres termes, les termes d'erreur des cinq équations décrites par (1) ne sont pas corrélés entre eux. De plus, les éléments diagonaux de la matrice $E[U_t U_t']$ ont une valeur de un, et représentent l'amplitude des chocs structurels. Ces chocs ont en outre une interprétation économique valide, car ils représentent une innovation dans une unique variable. Dans ce mémoire nous nous concentrons sur des chocs de prix de matières premières, créés par une variation unitaire de U_{Pt}.

3.1.2. Forme réduite du modèle structurelle.

Le modèle présenté plus haut ne peut pas être directement utilisé, c'est pourquoi sa forme réduite (c'est-à-dire sans interactions contemporaines entre variables prises en compte par la matrice Θ) est d'abord estimée, afin de pouvoir dans un second temps identifier Θ. Le modèle peut être réécrit sous sa forme réduite de la manière suivante :

$$\Delta X_t = \Theta^{-1}\delta + \Theta^{-1}\Pi X_{t-1} + \Theta^{-1}\Phi_1 \Delta X_{t-1} + \Theta^{-1}\Phi_2 \Delta X_{t-2} + \ldots + \Theta^{-1}\Phi_p \Delta X_{t-p} + \Theta^{-1}U_t,$$

$$\Delta X_t = c + \pi X_{t-1} + B_1 \Delta X_{t-1} + B_2 \Delta X_{t-2} + \ldots + B_p \Delta X_{t-p} + V_t,$$

avec $V_t = \Theta^{-1}U_t$ et $E[V_t V_t'] = \Sigma = \Theta^{-1}\Theta^{-1}{}' \neq I$. Les erreurs statistiques Vt de la forme réduite ne sont pas orthogonales, leur matrice de variance covariance, Σ, contient en effet des éléments diagonaux non nuls. Par conséquent, les chocs statistiques n'ont pas de réelles interprétations économiques, car ils représentent une combinaison linéaire de chocs structurels.

En outre, le modèle SVECM estimé peut être réécrit sous une forme réduite de VAR(1) (soit un VAR incluant un retard), ce qui, comme nous allons le voir, est utile pour calculer les réponses des variables suite à des chocs structurels. Ces réponses ne dépendant pas des constantes inclues dans le vecteur δ, ce dernier est omis dans les calculs suivants. En partant d'un SVECM(1), bien que le processus fonctionne avec n'importe quelle structure de retard, il est possible d'obtenir un VAR(1) de la façon suivante.

Le SVECM(1) sans vecteur de constante est décrit par :

$$\Theta \Delta X_t = \Pi X_{t-1} + \Phi_1 \Delta X_{t-1} + U_t .$$

Ce modèle peut alors être réécrit comme un SVAR(2) :

$$\Theta X_t = (\Pi + \Theta + \Phi_1) X_{t-1} - \Phi_1 X_{t-2} + U_t ,$$

$$\Theta X_t = \Lambda_1 X_{t-1} + \Lambda_2 X_{t-2} + U_t ,$$

avec $\Lambda_1 = \Pi + \Theta + \Phi_1$ et $\Lambda_2 = -\Phi_1$.

Cette forme peut etre résumée en un SVAR(1) :

$$\begin{pmatrix} \Theta & 0 \\ 0 & I \end{pmatrix} \begin{pmatrix} X_t \\ X_{t-1} \end{pmatrix} = \begin{pmatrix} \Lambda_1 & \Lambda_2 \\ I & 0 \end{pmatrix} \begin{pmatrix} X_{t-1} \\ X_{t-2} \end{pmatrix} + \begin{pmatrix} U_t \\ 0 \end{pmatrix},$$

ou sous forme matricielle :

$$\mathrm{T} Z_t = \Phi Z_{t-1} + E_t , \qquad (2)$$

avec $\mathrm{T} = \begin{pmatrix} \Theta & 0 \\ 0 & I \end{pmatrix}$, $Z_t = \begin{pmatrix} X_t \\ X_{t-1} \end{pmatrix}$, $\Phi = \begin{pmatrix} \Lambda_1 & \Lambda_2 \\ I & 0 \end{pmatrix}$ et $E_t = \begin{pmatrix} U_t \\ 0 \end{pmatrix}$.

Le modèle VAR(1) correspondant est alors la forme réduite suivante :

$$Z_t = \Gamma Z_{t-1} + \nu_t , \qquad (3)$$

avec $\Gamma = \mathrm{T}^{-1}\Phi$ et $\nu_t = \mathrm{T}^{-1} E_t$.

3.1.3. Identification du modèle structurel

Une fois le modèle en forme réduite estimé, des restrictions d'identification doivent être imposées afin de pouvoir identifier la matrice Θ. Ces restrictions sont illustrées avec un modèle SVAR(1), dont le vecteur X_t contient cinq variables (N=5), comme dans le SVECM estimé pour chaque pays :

$$\Theta X_t = \Phi X_{t-1} + U_t. \tag{4}$$

Sa forme réduite est :

$$X_t = \Gamma X_{t-1} + V_t.$$

avec $\Gamma = \Theta^{-1}\Phi$ et $V_t = \Theta^{-1}U_t$.

Ce SVAR(1) comprenant cinq variables, les matrices Θ et Φ contiennent chacune N^2=25 éléments, il nous faut donc obtenir 50 éléments au total. Cependant, l'estimation de sa forme réduite ne nous fournit que 25 éléments venant de Γ et N(N+1)/2 = 15 éléments distincts venant de la matrice de variance-covariance Σ des erreurs statistiques V_t, donnée par $\Sigma = E[V_t V_t'] = \Theta^{-1}\Theta^{-1}{}'$. Nous obtenons 40 éléments estimés au total, il nous manque alors N(N-1)/2 = 10 éléments, qui ne peuvent pas être identifiés. Le nombre de paramètres inconnus dépasse donc le nombre de paramètres estimés de 10, c'est pourquoi nous définissons 10 éléments de Θ comme nuls, cette matrice devenant alors triangulaire inférieure. Par conséquent, une variable donnée dans l'ordonnancement est contemporainement influencée par les variables qui la précèdent dans le vecteur X_t. Ces restrictions peuvent être visualisées avec une matrice Θ et un vecteur X_t explicites dans le modèle SVAR(1) :

$$\begin{pmatrix} \theta_{11} & 0 & 0 & 0 & 0 \\ \theta_{21} & \theta_{22} & 0 & 0 & 0 \\ \theta_{31} & \theta_{32} & \theta_{33} & 0 & 0 \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} & 0 \\ \theta_{51} & \theta_{52} & \theta_{53} & \theta_{54} & \theta_{55} \end{pmatrix} \begin{pmatrix} P_t \\ I_t \\ Y_t \\ R_t \\ Q_t \end{pmatrix} = \Phi X_{t-1} + U_t.$$

3.2. Effet direct et indirect d'un choc de prix des matières premières sur le taux de change réel

3.2.1. Décomposition des effets direct et indirect

Le but de ce mémoire est de quantifier l'importance de deux relations : l'effet direct des matières premières sur le taux de change réel, et leur effet indirect, à travers les fondamentaux économiques qui peuvent également influencer ce taux de change. C'est pourquoi nous séparons la réponse du taux de change à un choc de prix des matières première en deux effets. D'abord, un effet direct qui ne dépend que de la variation du cours des matières premières et qui ne peut pas être expliqué par les variables fondamentales inclues dans le modèle. Ensuite, un effet indirect qui dépend de l'impact des variables fondamentales (prix à la consommation, PIB réel et taux d'intérêts réels) et des réponses passées du taux de change sur le taux de change courant. Cette décomposition est effectuée en utilisant une approche similaire à celle de Bachman et Sims (2012), qui a été introduite par Bernanke et al. (1998). Cependant, contrairement à ces articles qui se concentrent alternativement sur l'effet direct ou indirect de certains chocs, ce mémoire s'intéresse à la fois aux effets direct et indirect de chocs dans le prix des matières premières.

Cette décomposition des réponses du taux de change en deux effets deviendra plus claire une fois illustrée par un exemple. Nous allons d'abord calculer ces réponses dans le cas d'un modèle SVAR(1), forme sous laquelle notre SVECM peut être réécrit comme démontré en (2). Cependant, dans un souci de clarté, nous considérons un modèle ne comprenant que trois variables : le prix des matières premières, P_t, une variable fondamentale susceptible d'influencer le taux de change, le PIB réel, Y_t, et le taux de change réel, Q_t.

Le modèle devient alors :

$$\begin{pmatrix} \theta_{11} & 0 & 0 \\ \theta_{21} & \theta_{22} & 0 \\ \theta_{31} & \theta_{32} & \theta_{33} \end{pmatrix} \begin{pmatrix} P_t \\ Y_t \\ Q_t \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} & \phi_{13} \\ \phi_{21} & \phi_{22} & \phi_{23} \\ \phi_{31} & \phi_{32} & \phi_{33} \end{pmatrix} \begin{pmatrix} P_{t-1} \\ Y_{t-1} \\ Q_{t-1} \end{pmatrix} + \begin{pmatrix} U_{Pt} \\ U_{Yt} \\ U_{Qt} \end{pmatrix}.$$

Il peut être réécrit sous forme matricielle :

$$\Theta X_t = \Phi X_{t-1} + U_t, \tag{5}$$

et possède comme forme réduite le VAR(1) suivant :

$$X_t = \Gamma X_{t-1} + V_t. \tag{6}$$

En appliquant une substitution récursive sur le VAR(1) décrit par l'équation (6), on obtient :

$$X_t = V_t + \Gamma V_{t-1} + \Gamma^2 V_{t-2} + \ldots + \Gamma^t V_0, \tag{7}$$

$$X_t = \Theta^{-1} U_t + \Gamma \Theta^{-1} U_{t-1} + \Gamma^2 \Theta^{-1} U_{t-2} + \ldots + \Gamma^t \Theta^{-1} V_0.$$

A partir de l'équation (7), il est possible de calculer les réponses d'impact de nos variables, c'est-à-dire leur réaction suite à un choc structurel dans le prix des matières premières, le PIB réel ou le taux de change réel.

Les réponses contemporaines (c'est-à-dire les réactions instantanées de variables à un choc) peuvent être calculées analytiquement une fois que le SVECM est estimé et identifié, et que les matrices Θ et Φ sont connues. Nous allons d'abord calculer la réponse du taux de change réel à un choc contemporain dans le prix des matières premières. D'après (5), le taux de change réel est définit de la manière suivante :

$$\theta_{33} Q_t = -\theta_{31} P_t - \theta_{32} Y_t + \phi_{31} P_{t-1} + \phi_{32} Y_{t-1} + \phi_{33} Q_{t-1} + U_{Qt}. \tag{8}$$

Cependant, le choc que l'on considère est contemporain. Dans ce contexte, les termes en $_{t-1}$ ne jouent aucun rôle, ils sont donc considérés comme nuls dans l'équation suivante. (8) devient ainsi :

$$\theta_{33} Q_t = -\theta_{31} P_t - \theta_{32} Y_t + U_{Qt}.$$

Et la réponse du taux de change est donnée par :

$$\frac{\partial Q_t}{\partial U_{Pt}} = \left(-\frac{\theta_{31}}{\theta_{33}} \times \frac{\partial P_t}{\partial U_{Pt}} \right) + \left(-\frac{\theta_{32}}{\theta_{33}} \times \frac{\partial Y_t}{\partial U_{Pt}} \right) + \frac{1}{\theta_{33}} \times \frac{\partial U_{Qt}}{\partial U_{Pt}}. \quad (9)$$

Notons que, les erreurs structurelles étant orthogonales, un choc dans le prix des matières premières n'influence pas U_{Qt}. On peut alors voir d'après (9) que la réponse du taux de change se compose de deux effets. Un effet direct qui dépend de la variation du prix des matières premières, soit le premier terme entre parenthèses de (9), et un effet indirect qui dépend de l'effet des matières premières sur la variables fondamentale incluse dans le modèle, ici le PIB réel Y_t. Cet effet indirect est décrit par le second terme entre parenthèse de l'équation (9).

Cependant, afin de totalement calculer $\frac{\partial Q_t}{\partial U_{Pt}}$ il faut extraire les équations structurelles décrivant Y_t et P_t de (4), toujours en ne considérant que les termes contemporains :

$$\theta_{22} Y_t = -\theta_{21} P_t + U_{Yt} \text{ et } \theta_{11} P_t = U_{Pt}.$$

En substituant l'expression de P_t dans celle de Y_t on obtient :

$$\theta_{22} Y_t = -\frac{\theta_{21}}{\theta_{11}} U_{Pt} + U_{Yt}.$$

On peut désormais remplacer P_t et Y_t dans (8) :

$$\theta_{33} Q_t = -\frac{\theta_{31}}{\theta_{11}} U_{Pt} + \frac{\theta_{32}\theta_{21}}{\theta_{22}\theta_{11}} U_{Pt} - \theta_{32} U_{Yt} + U_{Qt}.$$

La réponse totale du taux de change à un choc dans le prix des matières premières est alors donnée par :

$$\frac{\partial Q_t}{\partial U_{Pt}} = \frac{\theta_{21}\theta_{32} - \theta_{22}\theta_{31}}{\theta_{11}\theta_{22}\theta_{33}} = \left(-\frac{\theta_{22}\theta_{31}}{\theta_{11}\theta_{22}\theta_{33}} \right) + \left(\frac{\theta_{21}\theta_{32}}{\theta_{11}\theta_{22}\theta_{33}} \right).$$

Comme mentionné plus haut, le premier terme entre parenthèses représente l'effet direct du choc de prix de matières premières, et le second terme entre parenthèses son effet indirect.

En utilisant l'écriture récursive donnée par (7), ces réponses contemporaines peuvent être obtenues d'une manière plus simple, étant donné que :

$$\frac{\partial X_t}{\partial U_t} = \frac{\partial V_t}{\partial U_t} = \Theta^{-1} = \begin{pmatrix} \theta_{11}^{-1} & 0 & 0 \\ -\frac{\theta_{21}}{\theta_{11}\theta_{22}} & \theta_{22}^{-1} & 0 \\ \frac{\theta_{21}\theta_{32} - \theta_{22}\theta_{31}}{\theta_{11}\theta_{22}\theta_{33}} & -\frac{\theta_{32}}{\theta_{22}\theta_{33}} & \theta_{33}^{-1} \end{pmatrix}. \qquad (10)$$

La réponse du taux de change calculée précédemment est ainsi donnée par l'élément (3,1) de cette matrice.

Les réponses d'impact correspondant aux périodes postérieures au choc peuvent être calculées en utilisant la même méthode à l'horizon temporel désiré. La seule différence entre les réponses contemporaines et les réponses postérieures au choc est que ces dernières dépendent aussi des réponses contemporaines. Par exemple, la réponse du taux de change à un choc dans le prix des matières premières ayant eu lieu il y a une période dépendra des réponses contemporaines comprises dans Θ^{-1}. Considérant l'équation (8), et en la réécrivant une période plus tard, on obtient :

$$\theta_{33}Q_{t+1} = -\theta_{31}P_{t+1} - \theta_{32}Y_{t+1} + \phi_{31}P_t + \phi_{32}Y_t + \phi_{33}Q_t + U_{Qt+1},$$

$$\frac{\partial Q_{t+1}}{\partial U_{Pt}} = \frac{1}{\theta_{33}}\left(-\theta_{31}\frac{\partial P_{t+1}}{\partial U_{Pt}} - \theta_{32}\frac{\partial Y_{t+1}}{\partial U_{Pt}} + \phi_{31}\frac{\partial P_t}{\partial U_{Pt}} + \phi_{32}\frac{\partial Y_t}{\partial U_{Pt}} + \phi_{33}\frac{\partial Q_t}{\partial U_{Pt}} + \frac{\partial U_{Qt+1}}{\partial U_{Pt}}\right),$$

$$\frac{\partial Q_{t+1}}{\partial U_{Pt}} = \left(-\frac{\theta_{31}}{\theta_{33}} \times \frac{\partial P_{t+1}}{\partial U_{Pt}} + \frac{\phi_{31}}{\theta_{33}} \times \frac{\partial P_t}{\partial U_{Pt}}\right) + \left(-\frac{\theta_{32}}{\theta_{33}} \times \frac{\partial Y_{t+1}}{\partial U_{Pt}} + \frac{\phi_{32}}{\theta_{33}} \times \frac{\partial Y_t}{\partial U_{Pt}}\right) + \left(\frac{\phi_{33}}{\theta_{33}} \times \frac{\partial Q_t}{\partial U_{Pt}}\right). \qquad (11)$$

D'abord, notons que le terme $\frac{\partial U_{Qt+1}}{\partial U_{Pt}}$ est nul, les innovations structurelles étant orthogonales et non corrélées dans le temps. Q_t étant contemporainement influencé par toutes les autres variables, sa réponse dynamique (c'est à dire après le choc initial) dépend à la fois des autres réponses dynamiques, $\frac{\partial P_{t+1}}{\partial U_{Pt}}$ et $\frac{\partial Y_{t+1}}{\partial U_{Pt}}$, et des réponses contemporaines calculées en (10) : $\frac{\partial P_t}{\partial U_{Pt}}$, $\frac{\partial Y_t}{\partial U_{Pt}}$ et $\frac{\partial Q_t}{\partial U_{Pt}}$. Par conséquent, $\frac{\partial Q_{t+1}}{\partial U_{Pt}}$ possède un composant de plus que notre réponse contemporaine : les réponses passées du taux de change au choc initial dans le prix des matières premières. L'effet direct, qui ne résulte que de variations du prix des matières premières, est identifié par le premier terme entre parenthèses dans (11). L'effet indirect dépend désormais à la fois de l'effet du cours des matières premières sur le PIB réel (deuxième terme entre parenthèses) et de la réponse passé du taux de change au choc initial (troisième terme entre parenthèses). Comme c'est le cas des réponses contemporaines, les réponses dynamiques peuvent être facilement calculées une fois que le modèle est identifié : en considérant (7), la matrice de réponse une période après un choc est donnée par $\Gamma\Theta^{-1} = \Theta^{-1}\Phi\Theta^{-1}$.

Dans la partie empirique de ce mémoire, cette décomposition est réalisée en deux étapes. D'abord, les effets direct et indirect sont séparés. Ensuite, l'effet indirect est décomposé en fonction de chaque variable qui le compose. Si l'on considère l'équation (11), cette seconde étape revient à séparer les deux derniers termes entre parenthèses. Cette méthode peut être utilisée avec n'importe quel horizon temporel et nombre de retards inclus dans le modèle. Le SVECM estimé pour chaque pays inclut cependant deux variables supplémentaires, l'indice des prix à la consommation et les taux d'intérêts réels. L'effet indirect possède ainsi quatre composantes : les prix à la consommation, le PIB réel, les taux d'intérêts réels et enfin les réponses passées du taux de change réel.

Chapitre 4 : "The rationale of commodity currencies: speculation or sound macroeconomic basis?"

Abstract

This paper investigates the economic foundation of the three main commodity currencies, the Australian, Canadian, and New Zealand dollars, by testing two hypotheses. The first one is that the impact of domestic commodity prices on real exchange rates is mostly driven by speculative demand or expectations about future exchange rate movements. The second one is that this impact is due to the effect of commodity prices on fundamental macroeconomic variables (such as CPI, real GDP, and real interest rates) and to the persistence of exchange rate variations following a commodity prices shock. Using a Structural Vector Error Correction Model (SVECM) for each one of the currencies we consider, our results suggest that, at the time of an unexpected rise in commodity prices, the resulting real exchange rate appreciation is almost entirely driven by its speculative part. However, after this unanticipated increase, the effect of fundamentals and the persistence of exchange rate variations dominate. This results in a negligible speculative effect in Australia and Canada, although it appears more sustainable in the case of New Zealand.

Keywords: Commodity currencies, Commodity economies, Exchange rates, Structural Vector Error Correction Model (SVECM), Vector AutoRegressive (VAR).

4.1. Introduction

The natural resources boom that occurred between 2000 and 2008 increased the interest of researchers in commodities, both from a financial and an economic perspective. One of the new focuses of the literature was the link between commodity prices and exchange rates, which appeared significant in countries that have substantial commodity exports. Among them are three developed economies, Australia, Canada, and New Zealand. In recent years, when both commodity prices and the exchange rates of these countries stood at record highs, it was not uncommon for government officials to state that their currency was overvalued. Indeed, policy makers are concerned with exchange rates, which are an important short-term determinant of the international competitiveness of domestic firms. These observations raise an interesting point: to what extent is the link between commodity prices and these currencies economically justified? The answer to this question has profound implications in terms of exchange rate policies. If the exchange rates of Australia, Canada, and New Zealand are explained by the effect of commodity prices on domestic macroeconomic fundamentals, then one can consider these rates as justified from an economic standpoint.[9] Foreign exchange interventions would then be unfounded. Conversely, if the effect of commodity prices on these exchange rates arises from factors other than fundamentals, one may argue that the considered currencies are especially prone to speculation. In this case, public statements or policy interventions designated to bring exchange rates closer to their fair value can be justifiable.

The goal of this paper is to measure the significance of two forces driving the exchange rates of currencies that are linked to commodity prices. On the one hand, we consider a speculative demand, or expectations about future exchange rates based solely on movements in commodity

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[9] In this article, “fundamental indicators” or “fundamentals” refer to the Consumer Price Index (CPI), the real Gross Domestic Product (GDP), and real interest rates.

prices. On the other hand, we isolate a fundamental demand, which results from the effect of commodity prices on macroeconomic fundamentals.

The literature dedicated to the interactions between commodity prices and exchange rates dates back to the late 1990s and is now substantial.[10] The concept of commodity currencies was first popularized by Chen and Rogoff (2003) who show that the real exchange rates of Australia, Canada, and New Zealand are significantly correlated to the real price of their commodity exports. This type of approach, linking commodity prices to exchange rates, was then extended to developing or emerging countries with results that are often significant at the 95% level of confidence.[11]

The rationale of commodity currencies can be defined as the various reasons why commodity prices significantly affect the exchange rates of countries with commodity currencies. In the literature, this rationale is usually explained through the export channel, which can be summarized as follows. As an important part of the commodities produced in a given country are exported, the improved trade balance resulting from higher commodity prices in turn increases the demand for the domestic currency, which appreciates as a consequence. To our knowledge, other reasons that could also explain the validity of the commodity currencies concept are seldom mentioned in the literature. As a result, this paper investigates the roles of two possible transmission channels between commodity prices and commodity currencies: speculation and fundamental macroeconomic indicators.

In other words, the present paper intends to analyze the causes of the link between commodity prices, as measured by domestic commodity price indices, and commodity currencies. This is done by separating the real exchange rate response to a domestic commodity prices shock into

[10] One of the earliest examples of this literature is the article of Amano and Van Norden (1998), which links the US dollar, the Japanese yen and the German deutschmark to oil prices.

[11] See for instance Bodart, Candelon and Carpentier (2011).

two effects, using an approach similar to that of Bachman and Sims (2012). The first effect is direct, because it solely depends on changes in commodity prices. It can be considered as speculative as it is not linked to any fundamental variable. The second effect is indirect and fundamental, since it is explained by both the impact of commodity prices on fundamentals and the persistence of exchange rate movements. To our knowledge, it is the first time this type of decomposition is applied to the study of commodity currencies.

The exchange rate response to a commodity prices shock is computed utilizing a Structural Vector Error Correction Model (SVECM), similar to that of King et al. (1991). The selected model is an extension of Structural Vector AutoRegressive (SVAR) models that allow each considered variable to influence the other ones through their lagged and, with some restrictions, current values. In order to allow for cointegration relations between variables, the SVECM additionally includes an error correction term. The five variables we consider are the domestic commodity prices index of each country, their real exchange rates vis-à-vis the US dollar as well as three macroeconomic fundamental indicators: the CPI, the real GDP, and the real interest rate. Australia, Canada, and New Zealand are studied using quarterly data ending in late 2012 but starting from different dates, as these countries did not float their currencies at the same time: Australia in 1983, Canada in 1970, and New Zealand in 1985. Finally, several robustness tests are performed using monthly data.

The decomposition of the real exchange rate response to a domestic commodity prices shock gives insightful and similar results across the three selected countries. At the time of the shock, the significant real appreciation is dominated by the speculative effect, which seems to embed expectations about future exchange rates. This effect is almost nil after one quarter in Australia and Canada, although it appears sustainable in New Zealand. One quarter after the shock and onwards, the real appreciation is mostly due to the fundamental effect. Due to the low duration of the speculative effect, one can assume that the link between commodity prices and commodity currencies primarily results from the effect of commodity prices on the considered economies.

Additionally, this article presents two other findings. First, the study of the fundamental effect itself exhibits different results among the countries we consider. In Australia and Canada, it is dominated at any time after the shock by the strong persistence of real exchange rate movements in response to a domestic commodity prices shock. As far as New Zealand is concerned, the CPI also plays a significant role: the increase in consumer prices following a positive commodity prices shock in turn contributes to the real appreciation of the New Zealand dollar.

Second, this paper supports the findings of the literature, by confirming the significant impact of commodity prices on both the real exchange rates and the macroeconomic fundamentals of the selected countries.[12] Overall, the real exchange rates, CPI and the real interest rates in all three countries are affected by a commodity prices shock at the 95% level of confidence, although the influence on real GDP is only significant in Canada.

The rest of this article is organized as follows. Section 4.2. reviews the past literature. It includes articles about commodity currency as well as empirical papers focusing on the commodity prices effect on fundamentals and exchange rates. Section 4.3. is dedicated to data description and analysis for each country. Section 4.4. presents the SVECM econometric model as well as our empirical results. Section 4.5. includes a robustness analysis using monthly data for Canada. Section 4.6. concludes.

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[12] See for instance Bloch et al. (2006) as well as Cologni and Manera (2008).

4.2. Literature review

The exchange rate literature has focused on explaining exchange rate movements with models including fundamental variables such as GDP, inflation, interest rates or exports, with generally mixed results. The absence of a consistent linkage between fundamentals and exchange rates in the data has been dubbed the “exchange rate disconnect puzzle” by Obstfeld and Rogoff (2000).

However, it is widely accepted that fundamentals remain valid exchange rates determinants, as noted by Sarno and Valente (2008): “Our evidence suggests that the exchange rate disconnect puzzle arising from our result is unlikely to be caused by lack of information in the fundamentals” (page 4). Besides, given their link to commodity prices, commodity currencies are less likely to be affected than other currencies by the exchange rate disconnect puzzle, as showed in Chen (2004).

Consequently, this literature review focuses on two types of papers. First, articles dealing with commodity currencies, which are the foundation of the economic question this paper tries to answer, and the reason why the ACNZ (Australia, Canada, and New Zealand) group is selected. Second, works that studied the impact of commodity prices on economic fundamentals that may affect exchange rates. The links between commodity prices and fundamentals are crucial to this paper as we later show that, considering the SVECM we estimate for each country, the exchange rate response to a commodity prices shock depends on these very links.[13] Unless stated otherwise, the use of term “significant” in the following review refers to significance at the 95% level of confidence.

[13] See section 4.4.2.1.

After going over articles individually, **Table 1** summarizes the findings of the literature regarding the effect of commodity prices on the economies of Australia, Canada, and New Zealand, so that they can be compared to our results.

4.2.1 The commodity currency literature

First of all, how is a commodity currency defined? The term was introduced by Chen and Rogoff (2003, 2012) in two articles that conclusively link the real commodity export prices of the ACNZ countries to their real exchange rates. Real exchange rates are regressed on real US dollar commodity prices, whose associated coefficients are significant at the 95% level of confidence. For robustness concerns, the authors measure exchange rates using different base currencies, such as the American dollar (USD), the Great Britain Pound (GBP), and the Japanese Yen (JPY). These different measures do not materially affect the results. Finally, the explanation of the link that is uncovered between real commodity prices and real exchange rates is solely based on the high share of exports commodities represent in each country, although this hypothesis is not empirically tested.

The commodity currency literature generally gives convincing results as far as the ACNZ group is concerned, and mostly consists of articles using real or effective (i.e. trade-weighted) exchange rates.[14] Yet, Chen (2004) shows that nominal exchange rates in the ACNZ countries are also significantly influenced by their commodity export prices. A Dynamics OLS (DOLS) procedure that allows for cointegration relations is selected, using quarterly data with two types of models in order to explain exchange rate movements. One type includes commodity prices as an explanatory variable, while the other type does not. Both model types include

[14] Articles solely based on the New Zealand dollar are quite rare. For a study devoted to the Australian dollar, see Hatzinikolaou and Polasek (2005) that finds an elasticity of the nominal Australian trade-weighted exchange rate to domestic commodity prices of 0.939.

money stocks (as measured by the monetary aggregates M1 and M0 in the UK), real GDP, inflation, and interest rates.[15] The results show that including commodity prices significantly improves the fit of the regressions for the three considered countries.

4.2.2. The dynamics between commodity prices, economic fundamentals and exchange rates

One of the goals of the present paper is to decompose the exchange rate response to a commodity prices shock in terms of the commodity prices effect on fundamentals. Therefore, our results partly depend on this effect, which has been extensively studied for the ACNZ group and developed countries. The following sections present a summary of the empirical literature that analyzed the commodity prices impact on the variables selected in the present article (exchange rates, interest rates, CPI, and GDP).

4.2.1.1. OLS regression models

Many articles using Ordinary Least Squares (OLS) regressions studied the link between commodity prices and economic fundamentals in developed economies. Due to their relative simplicity, these models usually assess the link between commodity prices and a single variable, typically inflation. They offer robust results for commodity economies, i.e. countries in which commodities represent an important part of exports or GDP, with a link between commodity prices and inflation that is often significant at the 95% or 99% levels of confidence.

Bloch, Dockery and Sapsford (2006) study the effect of world commodity prices, measured in US dollars from the IMF index of primary commodity prices (a basket of the main commodities worldwide), on inflation and nominal exchange rates in Australia and Canada.

[15] The author uses many different models; we only consider the most comprehensive one, the "Sticky prices monetary model". In this context, the variables are always relative, as measured by the ratio of one country's indicator to another's, each country representing a side of the considered foreign exchange quote.

This paper confirms the finding of Chen and Rogoff (2003), in that the currencies of both countries appreciate with the price of commodities. The authors also find that commodity prices are significant inflation determinants in both cases. Quarterly data is studied from 1973 (Australia) and 1960 (Canada), to 2011. The models selected include both Generalised Instrumental Variable Estimation (GIVE) and AutoRegressive (AR) ones, though the latter better fits the data.

More recently, a comprehensive review of the real commodity prices effect on inflation was done by Cheung (2009), studying a sample of industrialized countries that includes Australia, Canada, and New Zealand. The author shows that commodity prices significantly improve CPI inflation forecasts for the ACNZ countries, especially in the short-run, defined as one to two quarters ahead. AutoRegressive (AR) models are employed on quarterly data ranging from 1980 to 2007. In this 2009 article, commodity prices are measured in three different ways. First, by using the IMF index of primary commodity prices in US dollar terms. Second, using the same index in domestic terms. Third, by disaggregating the index with principal-component analysis. The author also performs analyses considering different time periods, post and pre-inflation targeting, and uses core as well as headline CPI. These robustness tests do not alter the conclusions of the article for the ACNZ group.

The previous results are corroborated by Hassan and Salim (2011), who test whether domestic commodity prices cause inflation in Australia, using cointegration and Granger causality tests on monthly data from 1982 to 2007. Both approaches are conclusive. These findings can be compared to the ones of our SVECM estimation, which employs the same commodity prices measure for Australia.

The literature overall suggests that a significant relation between commodity prices and inflation is to be expected for the ACNZ countries. However, the commodity prices effect on

GDP and interest rates did not attract as much research attention when only considering OLS-based models. This makes sense, considering that fundamental indicators such as GDP growth, inflation, and interest rates are all linked. Their mutual influences should therefore be accounted for, which is the purpose of the following type of econometric models.

4.2.1.2. VAR and VEC models

To our knowledge, recent econometric models such as SVAR and SVEC models have not been exclusively applied to the ACNZ group but rather to big developed economies in general.

Bloch et al. (2007) investigate the dynamics between GDP, the prices of finished goods, industrial wages, and commodity prices. Three countries are selected: the US, Japan, and the UK. The authors find a positive and significant relation between commodity prices and the prices of finished goods in Japan and the USA, while the significance is less pronounced in the UK. In this 2007 study, commodity prices are measured using the IMF index of primary commodity prices, translated to nominal domestic terms. Multiple econometric approaches are employed on quarterly data starting in 1957 and ending in 2001. They include OLS, AR models, GIVE, and finally a Vector Error Correction Model (VECM). The conclusions of the VECM are overall similar to those of simpler models; however the error correction term is significant, meaning that this type of model better fits the data.

Cologni and Manera (2008) analyze the effect of world oil prices among G-7 economies, considering five fundamental variables: real GDP, T-bill interest rates, inflation rates, the monetary aggregate M1, and exchange rates expressed as the Special Drawing Rights (SDRs) rate of the considered country to the US SDR rate.[16] In line with the findings of Bloch et al. (2006) and Cheung (2009), their results suggest very significant linkages between oil dollar

[16] The Special Drawing Rights or SDRs are a form of international reserve asset issued by the IMF.

prices and inflation for all countries except Japan and the UK, even if the G-7 only includes one commodity economy, Canada. Oil prices significantly affect output in three countries: negatively in Germany and the UK, and positively in Canada. The fact that Canada has both its output and inflation significantly increased by oil price shocks indicates that the model utilized in the present paper should deliver robust results for the ACNZ countries. However, no correlation is found between oil prices and interest rates or exchange rates for any country, although the way the exchange rates are measured using SDRs is unusual.

The authors use the structural version of a VECM (SVECM) with quarterly data from 1980 to 2003, and consider both long-term relations between variables (cointegration) and the short-term effects of an oil shock through impulse responses. The basic ideas behind a SVECM are twofold.[17] First, as an extension of Structural VAR (SVAR) models, it allows each considered variable to influence other ones through its lagged and, with some restrictions, current values. Second, it explicitly takes into account long-term relations between variables that appear to be cointegrated, which is often the case with long-run macroeconomic data.

Although the last article utilizes similar variables and the same model as the present paper, the two studies have significantly different goals. First, we intend to analyze the impact of changes in domestic commodity prices, as opposed to selecting a single strategic resource such as oil. Second, as exchange rates are a key variable in our study, they are measured using market rates, as opposed to SDRs that are subject to IMF definitions. Third, a major difference comes from the impulse response analysis employed to measure the effect of shocks affecting the exchange rate. In addition to a standard impulse response analysis, this paper separates the exchange rate response to a commodity prices shock into two effects, in order to disentangle purely commodity-induced exchange rate variations from movements that arise from a change in fundamentals.

[17] This type of model was introduced by King et al. (1991).

Finally, a recent paper by Le and Chang (2011) contradicts multiple conclusions of previous articles. Their study is dedicated to Japan and intends to analyze the effects of both oil and gold real prices on Japanese fundamentals such as real stock prices, nominal domestic interest rates, and nominal exchange rates vis-à-vis the US dollar. A short-term, positive link between real gold prices and interest rates is uncovered, suggesting some commodities have a significant impact on interest rates even outside of the commodity economies. The hypothesis of a commodity prices impact on interest rates is tested for the ACNZ countries in our model. The authors employ a VECM and its error-correction term is significant, supporting the SVECM selection made in the present paper. Whereas most similar studies are realized with quarterly data, monthly data is used from 1986 to 2011. This frequency difference may explain why the authors find a long-run positive relation (cointegration) between interest rates and oil prices, whereas in Cologni and Manera (2008) these variables did not appear linked in Japan.

Table 1. Summary of the literature dedicated to the commodity prices effect on the economies of Australia, Canada, and New Zealand.

Article	Model type	Countries	Significant commodity prices effect on: Exchange rate	Inflation	Interest rates	GDP
Chen and Rogoff (2003, 2012)	OLS, AR	Australia, Canada, and New Zealand	+	NA	NA	NA
Chen (2004)[18]	DOLS	Australia and New Zealand	+	NA	NA	NA
		Canada	-[19]	NA	NA	NA
Hatzinikolaou and Polasek (2005)	VECM	Australia	+	NA	NA	NA
Bloch, Dockery and Sapsford (2006)	GIVE, AR	Australia and Canada	+	+	NA	NA
Cheung (2009)	AR	Australia, Canada, and New Zealand	NA	+	NA	NA
Hassan and Salim (2011)	ECM, Granger[20]	Australia	NA	+	NA	NA
Cologni and Manera (2008)	SVECM	Canada	none[21]	+	none	+

Notes. Plus and minus signs denote an effect that is significant at the 95% level of confidence. Otherwise, "none" signals weaker influences. A plus sign indicates that a rise in commodity prices increases the considered variable, or appreciates a given exchange rate. NA is used when an article did not include a certain variable.

[18] The results of the most comprehensive model are reported, the "Sticky prices monetary model" that allows for cointegration relations, with US dollar-based exchange rates.

[19] According to the author, this unexpected result reverses when different time periods are considered. For a study of structural breaks in the relation between the Canadian dollar and oil prices, see Issa, Murray and Lafrance (2006).

[20] In this paper, the authors utilize both an Error Correction Model (ECM) to account for cointegration, and Granger causality tests using the commodity prices as a leading inflation indicator.

[21] This surprising result probably arises from the selected measure of exchange rates, which depends on the SDR exchange rates defined by the IMF.

4.3. Data

This paper intends to measure the importance of two effects that explain the movements of commodity currencies. First, the direct effect of commodity prices on exchange rates. Second, the indirect effect of commodity prices on exchange rates, through macroeconomic fundamentals. The exchange rate is therefore the variable that we try to explain with commodity prices and fundamentals. The following paragraphs include a description of three types of variables: exchange rates, commodity prices and macroeconomic fundamentals such as real GDP, real interest rates, and consumer prices. These fundamentals are included in the SVECM as they are all key indicators of macroeconomic performance. Also, clear links between commodity prices, exchange rates and some of these variables were uncovered for the ACNZ group, as summarized in **Table 1**.

Australia, Canada, and New Zealand are studied during different time periods as their currencies were not floated at the same time: Canada in 1970, Australia in 1983 and New Zealand in 1985. The series of commodity prices that are used in this paper were initiated shortly after those changes of exchange rate regime. Although some of the variables are high frequency ones, such as exchange rates or interest rates, the availability of GDP and inflation data is usually limited to a quarterly basis. As a consequence, the three selected countries are studied with quarterly data. Additionally, a robustness analysis using monthly data is performed for Canada.[22] In each sample the monthly or quarterly of higher frequency data (i.e. real exchange rates and real interest rates) is utilized.

[22] Such tests are not possible for Australia and New Zealand, which both report their Consumer Price Index (CPI) quarterly, while Canada reports it monthly. As real GDP is not available on a monthly basis, it is approximated by the Canadian index of industrial production. Another robustness test additionally includes trade balance instead of real GDP in Canada.

The data that was selected in the present paper is generally collected from the IMF International Financial Statistics database, apart from the commodity prices measure whose origin is explained in section 4.3.2.2. Data sources are exposed in detail in appendix A.

4.3.1. Variables description

4.3.1.1. Exchange rates

The chosen exchange rate measure is the real exchange rates vis-à-vis the US dollar, measured as $q = SP^* / P$. In this paper, S denotes the quarterly or monthly average of the nominal exchange rate in terms of local currency units per US dollar, P^* stands for the US CPI and P is the domestic CPI of Australia, Canada, or New Zealand. In this context, an increase in q represents a real exchange rate depreciation, i.e. a loss of international purchasing power. We intend to disentangle the effect of a commodity prices shock on exchange rates and inflation. Consequently, using real exchange rates allows us to purge the influence of domestic prices on exchange rates. That influence can be easily illustrated with an example: an increase in commodity prices could increase the domestic CPI and the higher CPI could, in turn, depreciate the local currency in nominal terms. In this example, the effect of a commodity price increase on exchange rates depends solely on inflation and not directly on commodity prices movements. Selecting a real exchange rate therefore allows us to effectively disentangle exchange rates and CPI responses to a commodity prices shock.

The exchange rate vis-à-vis the US dollar is used because the US dollar is the numéraire of most commodities included in the considered indices and the most important trade currency. Therefore, the analysis of adjustments following changes in commodity prices can be performed easily, with a single reference currency, the US dollar.

4.3.1.2. Commodity prices

The measures of commodity prices employed in this thesis consist of domestic commodity price indices: the Bank of Canada Commodity Price Index (BCPI), the Reserve Bank of Australia (RBA) Index of Commodity Prices and the ANZ Bank Commodity Price Index, computed by a private institution -the ANZ Banking Group- for New Zealand. The selected composite indices allow us to measure the effective commodity prices effect on each country by considering the impact of domestically produced commodities, as opposed to approaches that only consider one world index of commodity prices. In the domestic indices, weights depend on the domestic level of commodity production (BCPI) or on the contribution of commodities to exports (ANZ Bank and RBA Index of Commodity Prices). As explained in the previous subsection, commodity prices are measured in US dollars, as it is the main commodity price numéraire in world markets.

Moreover, the loss of information induced by using a composite index rather than each of its components individually, which could occur in case of negative or weak correlations between components, is minimal. Indeed, as tables 2, 3, and 4 show, correlations between the components of the individual indices are always positive.

As each country produces different commodities, an explanation of each index is necessary, including a description of components and their paired correlations, calculated using monthly data.

Australia's index (the RBA Index of Commodity Prices) involves three components: rural commodities (mostly containing meat, wheat, and wool), non-rural commodities (mainly including coal, iron ore, gold, natural gas, crude oil, and alumina) and base metals (mostly aluminum, copper, and lead). The weights corresponding to each component significantly changed over time. For instance, pre-1998, the weight attributed to the non-rural component was 48.3%; rural commodities represented 40.8% of the index, and base metals 10.9%. In 2008, weights changed to 77.9%, 12.5% and 9.6%, respectively. These important fluctuations reflect the significant and worldwide increase in metals and energy prices that started in the late 1990s.

Table 2. RBA Index of Commodity Prices paired correlations between components and index.

	Index	Rural	Non-rural	Base metals
Index	1	0.93	1.00	0.81
Rural	-	1	0.92	0.84
Non-rural	-	-	1	0.80
Base metals	-	-	-	1

Notes. This table presents paired correlations between the domestic commodity prices index and its components, as well as between components. They are calculated using monthly index values in US dollars.

As we can see in **Table 2**, the loss of information induced by selecting the index, as opposed to each of its component individually, is fairly low. Each component is indeed highly correlated with the overall index, the lowest correlation being superior to 0.8.

The Bank of Canada Commodity Price Index (BCPI) has five components that are more disaggregated, but the paired correlations remain strongly positive across any components (see **Table 3**). The energy component includes three crude oil measures (West Texas Intermediate, Brent and Western Canada Crude) as well as natural gas. Its weight in the index rose rather steadily from around 20% in the 1970s to more than 50% in the last years, whereas the agriculture component fell from 30% to around 12%. Metals always stood at around 20%

while fish is almost insignificant (1% to 2%). Forestry fell from 30% to 10% following the late 1990s metals and energy uptrend.

As **Table 3** shows, the Fish and Forestry parts have a lower correlation to the BCPI but they all remain largely positive.

Table 3. BCPI paired correlations between components and index

	Index	Energy	Metals and Minerals	Agriculture	Fish	Forestry
Index	1	0.98	0.94	0.83	0.71	0.64
Energy	-	1	0.88	0.79	0.65	0.54
Metals and Minerals	-	-	1	0.85	0.63	0.61
Agriculture	-	-	-	1	0.41	0.43
Fish	-	-	-	-	1	0.84
Forestry	-	-	-	-	-	1

Notes. See **Table 2.**

Finally, the ANZ Commodity Price Index is made of six components that, in comparison with the previous indices, are fairly homogeneous and self-explanatory. Cross correlations all remain positive, and the correlations between the index and the components are lower for the components that are associated with the lower weights. In 2012, the horticultural products weight was 5.9%, that of forestry was 13.1%, and that of aluminum 5.1%. Those numbers should be contrasted to the 42.8% and 27.6% contributions of dairy products and meat, skins, and wool.

Table 4. ANZ Commodity Price Index paired correlations between components and index

	Index	Meat Skins and Wool	Dairy Products	Horticultural Products	Forestry Products	Seafood	Aluminum
Index	1	0.93	0.94	0.54	0.63	0.83	0.68
Meat Skins and Wool	-	1	0.78	0.44	0.57	0.75	0.55
Dairy Products	-	-	1	0.49	0.62	0.78	0.69
Horticultural Products	-	-	-	1	0.24	0.39	0.28
Forestry Products	-	-	-	-	1	0.39	0.59
Seafood	-	-	-	-	-	1	0.48
Aluminum	-	-	-	-	-	-	1

Notes. See **Table 2.**

4.3.1.3. Macroeconomic fundamentals

The next three variables are fundamental macroeconomic indicators that could be influenced by commodity prices in the selected countries. The influence of these variables on exchange rates has often been identified, theoretically or empirically, by the economic literature.

4.3.1.3.1. Real GDP

Real GDP is a major fundamental indicator, it impacts exchange rates through various channels and is closely linked to the other variables we consider. Firstly, it incorporates the trade balance, and exports have been identified by the commodity currency literature to be the main fundamental underpinning of the influence of commodity prices on exchange rates. The impact of commodity prices on real GDP is expected to be more significant in Australia and

New Zealand, which both have a higher proportion of commodities as a percentage of GDP and exports than Canada.[23] Also, one could assume that stronger real growth supports investor confidence in a country, thus increasing demand for its currency that could appreciate as a consequence.

4.3.1.3.2. Prices

According to empirical studies, an increase in the inflation rate of a country tends to depreciate its currency in nominal terms.[24] This result is theoretically backed, in the long run, by the relative purchasing power parity hypothesis, which expresses exchange rates movements in terms of inflation differentials between countries. As commodity prices are part of consumer prices and affect production costs as well, we expect relatively robust results concerning the link between commodity prices and inflation, as it was mentioned in the literature review. The inflation rate is measured using the growth rate in the Consumer Price Index (CPI) of each country.

4.3.1.3.3. Real interest rates

Real interest rates could indirectly be affected by commodity prices, as these prices are part of the CPI and influence production levels. As both GDP growth and inflation are closely monitored by monetary authorities, who in turn influence interest rate levels, multiple significant relations between these variables are expected.

An important literature is devoted to the effect of nominal interest rates on exchange rates. Existing studies have shown that in the short and medium run, i.e. less than 5 years, the

[23] See Chen and Rogoff (2003), page 3.

[24] See Rogoff (1996) for a comprehensive literature review.

uncovered interest parity (UIP) does not hold, as when nominal interest rates rise in a country, its currency tends to appreciate since local investments become more attractive to short-term investors.[25] In the long run, however, the UIP seems to hold fairly well, since a higher nominal interest in a foreign country leads to a depreciation of its currency, thus preventing long-run arbitrages. With both time-horizons, the impact is significant: rises in nominal interest rates appreciate the exchange rate in the short run, and depreciate it in the long run.

However, as nominal interest rates also embed inflation expectations, real interest rates are used in order to disentangle pure interest rates changes from changes in actual or expected inflation. As some of our key variables are high-frequency ones (exchange rates, interest rates and commodity prices), we focus on the shorter end of interest rates. Specifically, we only include one measure of real interest rates in the model, a short to medium rate, the 5-year government bond yield of the selected country, net of the domestic CPI inflation.[26] Given that the chosen 5-year rate is usually a limit between short and long rates in the UIP literature, it is hard to predict the effect it will have on exchange rates.

4.3.2. Graphical evidence

Figures 1, 2, and 3 show the growth rates of all considered variables except the real interest rates for each country (i.e. the domestic commodity prices index, the real GDP, the CPI, and the real exchange rate of the considered currency vis-à-vis the US dollar). The real interest rates on 5-year government bonds are presented in levels as they are already expressed in percentage terms.

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[25] See for instance Meredith and Chinn (1998)

[26] Note that for Canada, 5-year yields were available only from 1980 and onwards. In order to study the country from 1972, the average 3 to 5-year Canadian government bond yields are selected, as they are available from 1959.

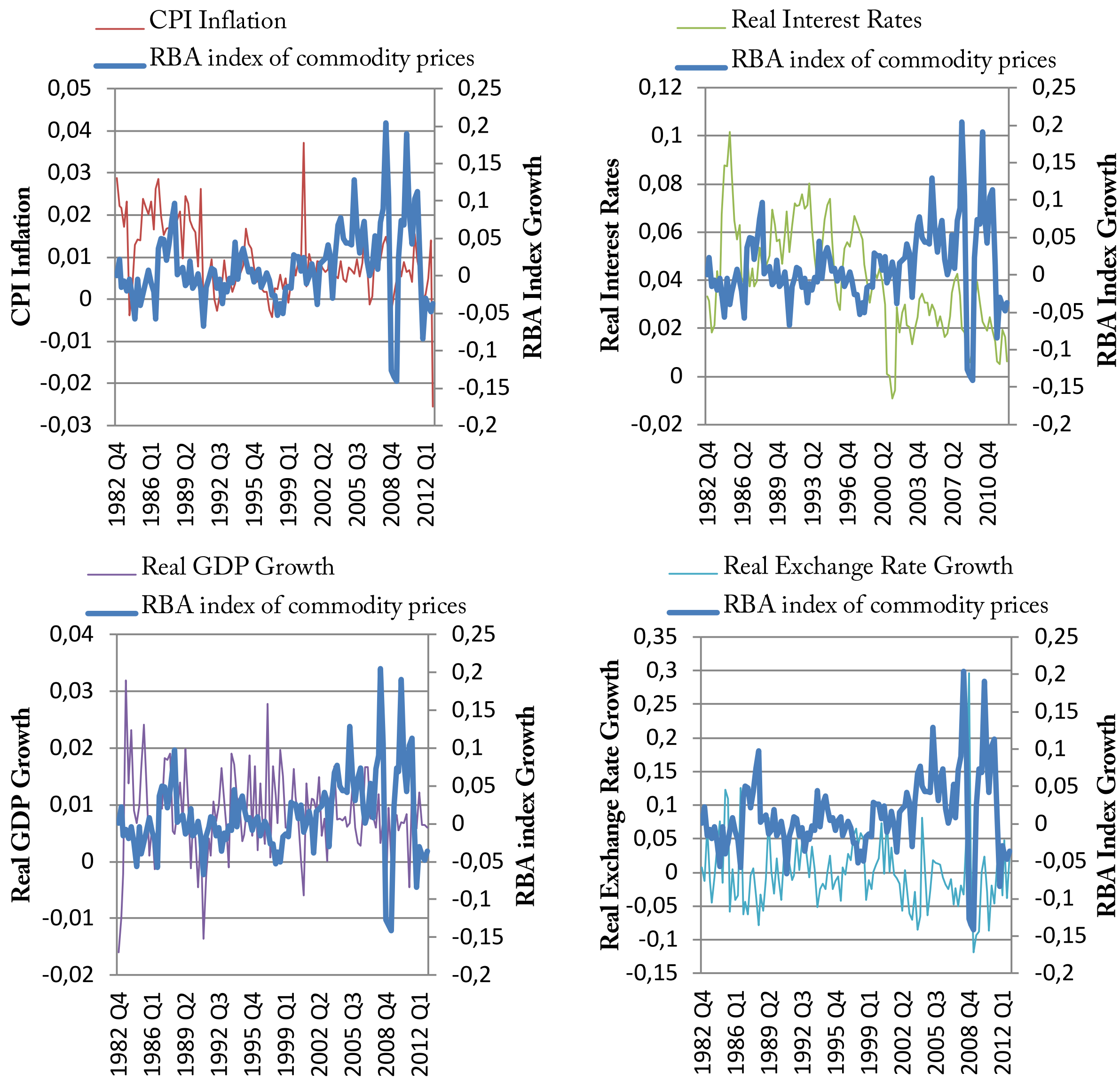
Several features clearly appear in all three countries (see figures 1, 2, and 3). We can first notice that commodity price indices and real exchange rates move in opposite direction: an increase in commodity prices lowers the real exchange rate, which corresponds to a real appreciation of the domestic currency.[27] This is consistent with the commodity currency literature findings, and is visible in all three countries.

Another common feature, despite the use of domestic commodity price indices, is the strong increase in commodity prices volatility since the 2000s: Canada seems to be affected earlier, with increased variability starting in 1999, while both the Australian and New Zealand indices start to exhibit marked increases from 2003 and onwards. The total increase over the study period is lower for New Zealand, where the local commodity price index doubled at its peak in 2011, while the Canadian and Australian one were respectively multiplied by nine from 1972 to 2008 and by four from 1982 to 2011. Finally, the real interest rates are sometimes much more volatile than the other series and it is often hard to graphically identify meaningful correlations with other variables.

[27] The correlation between the growth rate of the real exchange rate and the growth rate of the domestic commodity prices index is negative in the three selected countries: -0.35 in Australia and New-Zealand, and -0.44 in Canada. These values are computed using quarterly data in US dollar terms.

4.3.1.1. Australia

Figure 1. Growth rates of Australian commodity prices (RBA Index), CPI, real GDP, and real exchange rates. Real interest rates are presented in levels.

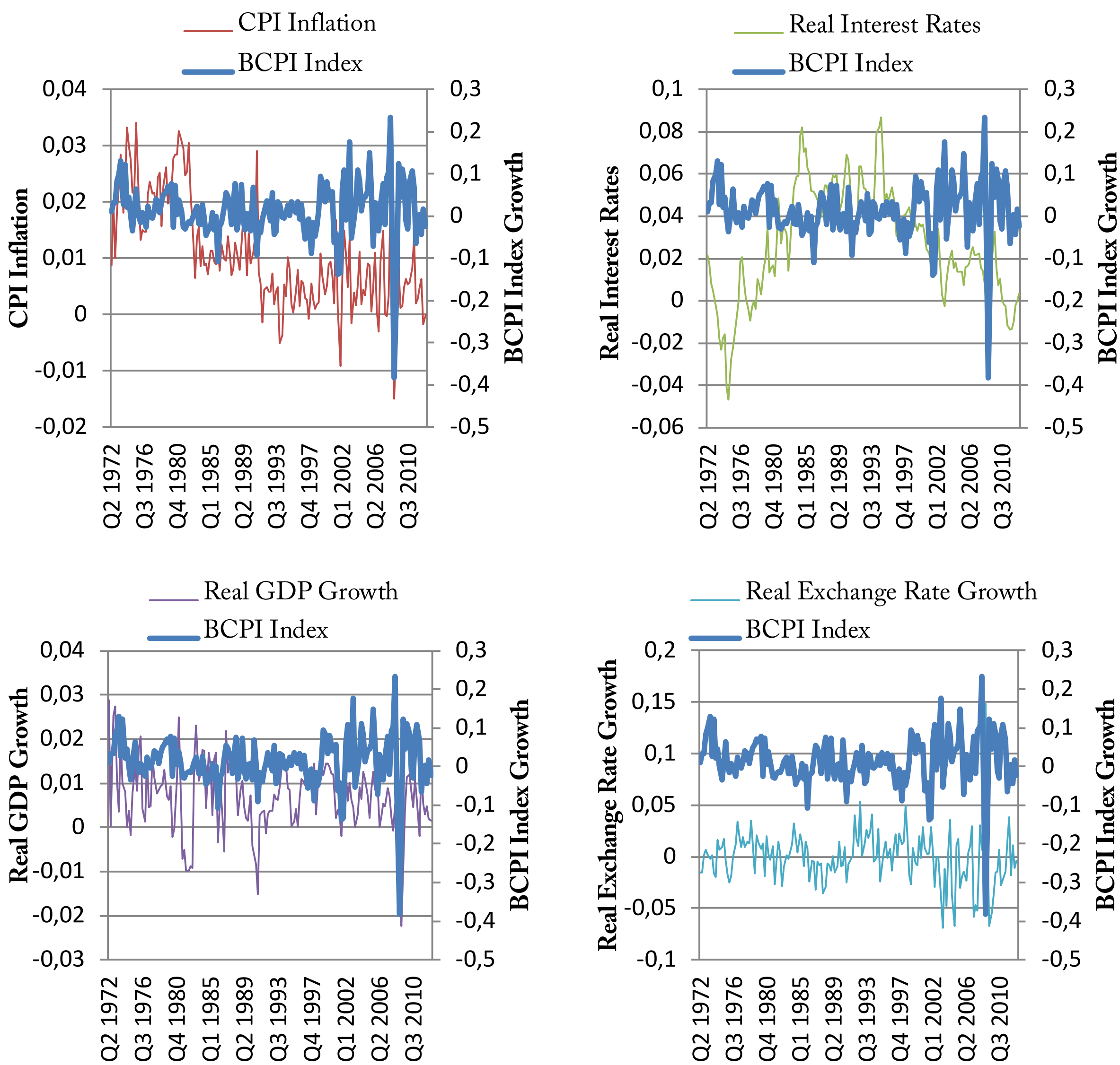


Notes. The thick lines (corresponding to the right axes) represent the growth rate of the domestic commodity prices index, while the thin lines (corresponding to the left axes) represent the growth rate of the CPI, real GDP or real exchange rates, or the level of real interest rates.

As far as Australia is concerned, the domestic commodity prices index seems to be strongly and positively linked to CPI. Also, a slight negative correlation (-0.15) appears between the growth in commodity prices and real interest rates, though it is hard to tell whether that effect in turn influences real exchange rates. The real GDP growth also seems unrelated to commodity prices (the correlation between those variables is close to zero), unlike the CPI inflation which exhibits a 0.2 correlation with the growth in commodity prices.

4.3.1.2. Canada

Figure 2. Growth rates of Canadian commodity prices (BCPI Index), CPI, real GDP, and real exchange rates. Real interest rates are presented in levels.

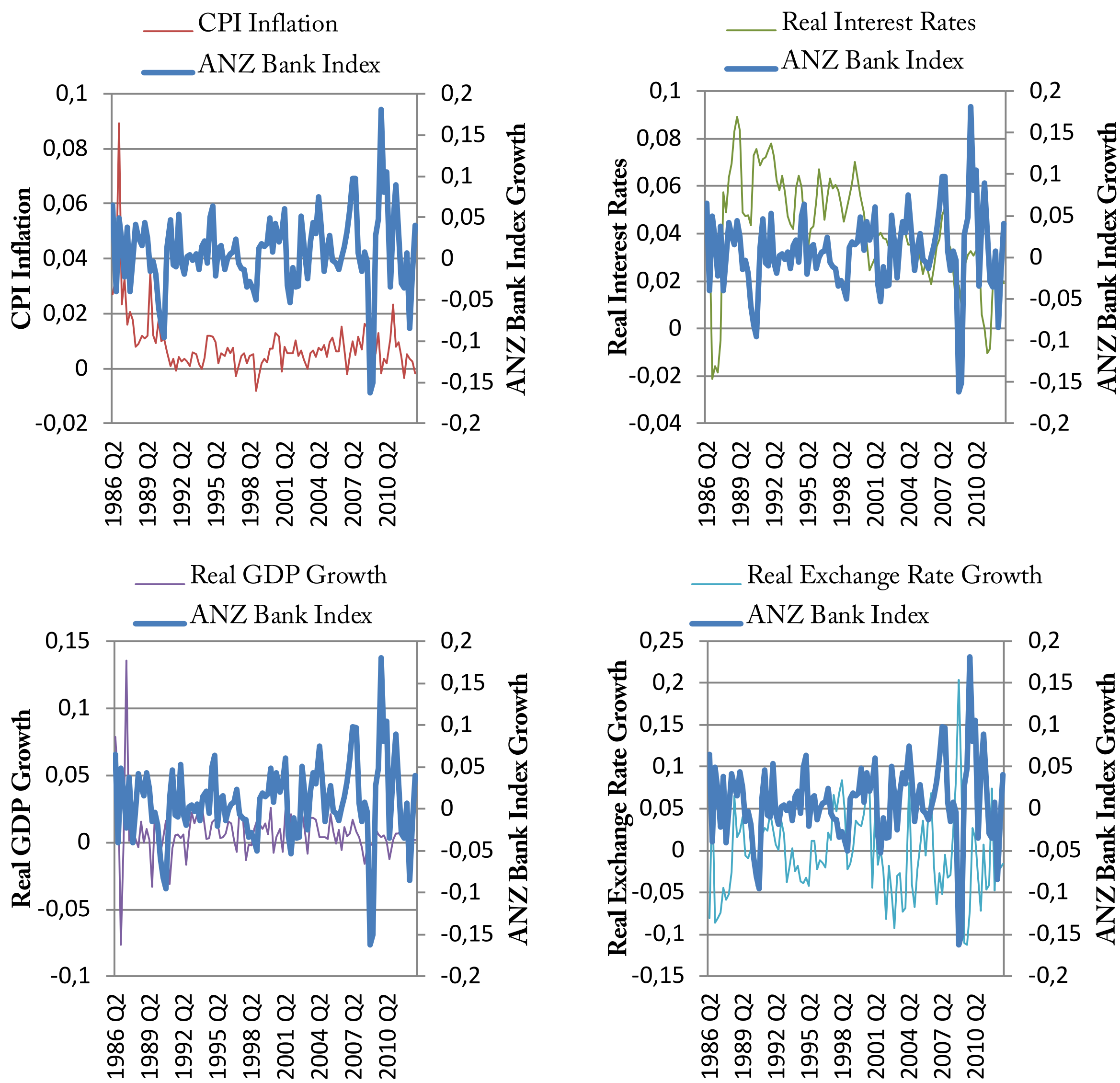


Notes. See **Figure 1.**

The Canadian CPI inflation co-moves positively with the BCPI, even after the marked increase in prices variability experienced from the 1990s, as the correlation between these two variables is 0.3. The Canadian real GDP growth also appears to be positively correlated to the BCPI variations overtime, with a correlation of 0.28. It is harder to graphically identify correlations with the real interest rates, which are much more volatile than other series.

4.3.1.3. New Zealand

Figure 3. Growth rates of New Zealand commodity prices (ANZ Bank Index), CPI, real GDP, and real exchange rates. Real interest rates are presented in levels.



Notes. See **Figure 1.**

Two facts seem to distinguish New Zealand from the previous countries. First, the increased volatility in commodity prices experienced by New Zealand after 2003 is less spectacular than in the Australian and Canadian cases. Second, graphically, there seems to be a positive long term linkage between the growth rate of the real exchange rate and the real interest rate,[28] as both series exhibit a downward trend throughout the sample period, which may reflect an indirect effect of commodity prices increase.

Although graphical analysis can provide useful intuition, the use of statistical models will help establishing which fundamentals are significantly affected by domestic commodity prices, and whether those fundamentals in turn influence exchange rates. However, before any statistical model is estimated, the data must be tested for unit roots (i.e. non-stationarity) and cointegration relations (long-term linkages of several variables).

4.3.3. Unit roots tests

For each country, all of the variables are tested for unit roots using the Augmented Dickey-Fuller (ADF) test. It is performed on logged level variables, with the exception of real interest rates that are sometimes negative, thus included in levels in the following tests. As the CPI and real GDP follow a relatively linear evolution overtime, their unit root tests include a time trend. The other variables (domestic commodity prices index, real interest rates and real exchange rates) have much less stable progressions, so they were tested for unit roots using the "random walk with drift" form of the ADF test. The number of lags included in each ADF test is determined by the Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC), using the largest number of lags recommended by either criterion, given an upper limit of 10 lags. The results of the tests are presented in details in appendix B.1.

In Australia, Canada, and New-Zealand, all of the selected variables exhibit unit roots at the 95% confidence level. For that reason, they are all included as their first differences in the

[28] The correlation between these two variables is 0.21.

SVECM. As the variables all contain unit roots, we now need to check for cointegration relations among them in order to obtain a properly specified model for each country.

4.3.4. Cointegration tests

Cointegration refers to several variables integrated of the same order, as it is the case if they all contain unit roots, sharing a common stochastic trend. The levels of these variables are linked in the long run, but can experience short-term deviation from a long-run equilibrium relation. This type of linkage can be incorporated in Vector Auto Regressive (VAR) models, using a Vector Error Correction (VEC) framework, which allows each cointegration relation to be explicitly taken into account. The Johansen test for cointegration is applied to all samples. As with the unit root tests, the cointegration test results are presented on a 95% confidence level basis. The Johansen test details are exposed in appendix D.1.

The tests indicate that one cointegration relation is to be included in the structural VEC model (SVECM) for both Australia and Canada, while two long-run relations have to be accounted for in the case of New Zealand. Note that the presented number of cointegration relations for each country is robust to changes in the lag structure used in the VEC(p) regressions of the Johansen test.

4.4. Econometric model and empirical results

This section describes in details the econometric model that is estimated for each country, and explains how the impact of a commodity prices shock on real exchange rates is analyzed and decomposed. Finally, the section includes our empirical results, which are threefold, as they include the responses of the chosen variables to a commodity prices shock, and a decomposition of both the total real exchange rate responses and its indirect part.

4.4.1. Econometric model

4.4.1.1. Description of the SVEC Model (SVECM)

A SVECM, pioneered by King et al. (1991), was selected for this paper. Its purpose is to study the dynamics between multiple variables that may be cointegrated, which is the case in all of the samples we consider (see section 4.3.4.). Standard OLS regressions or VAR models would fail to account for cointegration, thus producing biased results. The SVECM also enables us to compute the response of a variable of interest after an unanticipated increase in another variable. This response is a function of all the variables included in the model, which is how we intend to disentangle the exchange rate response to a commodity prices shock into a fundamental and a speculative effect.

4.4.1.2. Structural form model

A standard SVECM takes the following form:

$$\Theta \Delta X_t = \delta + \Pi X_{t-1} + \Phi_1 \Delta X_{t-1} + \Phi_2 \Delta X_{t-2} + \ldots + \Phi_p \Delta X_{t-p} + U_t . \qquad (1)$$

Five variables are contained in the vector X_t: the log of the commodity price measure, P_t, the log of the CPI, I_t, the 5-year real interest rates on government bonds,[29] R_t, the log of the real GDP, Y_t, and the log of the real exchange rate, Q_t. The ordering of the variables within the vector $X_t = (P_t \quad I_t \quad Y_t \quad R_t \quad Q_t)'$ will be discussed in subsection 4.1.3., which explains the identification of the model.

All of the variables contain unit roots, which is why they are studied through their first differences, included in the vector ΔX_t. The cointegration relations (one for Australia and Canada, and two for New Zealand) are accounted for by the matrix Π, as explained in the notes to appendix D.1. The matrix Θ takes contemporaneous interactions between the variables of interest into account. However, as it will be further explained in subsection 4.1.3., we cannot allow for each variable to be influenced contemporaneously by all the other ones, some identifying restrictions have to be imposed. The matrices Φ_i account for dynamics interactions between current and lagged variables and are not subject to any restriction. Finally, the δ vector contains one constant per structural equation.

An important point in a structural model is that the structural errors are orthogonal, i.e., the vector of structural errors U_t is such that $E[U_t U_t'] = I$, where U_t contains the error terms of the structural equations: $U_t = (U_{Pt} \quad U_{It} \quad U_{Yt} \quad U_{Rt} \quad U_{Qt})'$. In other words, each error term of the five structural equations contained in *(1)* is not correlated with the error term of the other equations, i.e. the non-diagonal elements of $E[U_t U_t']$ are nil. Additionally, its diagonal elements, which represent the variance of the error terms, are set to one. As a consequence the shocks U_t have a size that is normalized to one. The structural shocks U_t have a meaningful economic interpretation as they represent an initial disturbance in one and only one variable. In this article we focus on commodity prices shocks, captured by a unit variation of U_{Pt}.

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[29] To be exact, the average yield on 3 to 5-year marketable bonds for Canada.

4.4.1.3. Reduced form model

The model presented above cannot directly be estimated, which is why a reduced form, i.e. without including the contemporaneous interactions accounted for by the matrix Θ, is utilized first. The structural model is subsequently identified. The reduced form of the structural model can be obtained as follows:

$$\Delta X_t = \Theta^{-1}\delta + \Theta^{-1}\Pi X_{t-1} + \Theta^{-1}\Phi_1 \Delta X_{t-1} + \Theta^{-1}\Phi_2 \Delta X_{t-2} + \ldots + \Theta^{-1}\Phi_p \Delta X_{t-p} + \Theta^{-1}U_t,$$

$$\Delta X_t = c + \pi X_{t-1} + B_1 \Delta X_{t-1} + B_2 \Delta X_{t-2} + \ldots + B_p \Delta X_{t-p} + V_t,$$

where $V_t = \Theta^{-1}U_t$ and $E[V_t V_t'] = \Sigma = \Theta^{-1}\Theta^{-1}{}' \neq I$. The errors V_t of the reduced form are not orthogonal as their variance covariance matrix, Σ, contains non diagonal elements that are not nil. Consequently, V_t shocks do not have a meaningful economic interpretation as they are linear combinations of the structural shocks.

Also, it should be noted that the initial SVECM with any lag structure can be expressed as a simple reduced form VAR(1). This will help us to derive the exchange rate responses to a commodity prices shock. For illustration purposes we omit the vector of constants δ in the following derivations, as impulse responses are not influenced by these terms. Starting with a SVECM(1), though the process works with any lag structure, it is possible to rewrite the model as a VAR(1) in the following way.

The SVECM(1) equation is given by:

$$\Theta \Delta X_t = \Pi X_{t-1} + \Phi_1 \Delta X_{t-1} + U_t.$$

This model can then be rewritten into a SVAR(2) form:

$$\Theta X_t = (\Pi + \Theta + \Phi_1) X_{t-1} - \Phi_1 X_{t-2} + U_t,$$

$$\Theta X_t = \Lambda_1 X_{t-1} + \Lambda_2 X_{t-2} + U_t,$$

with $\Lambda_1 = \Pi + \Theta + \Phi_1$ and $\Lambda_2 = -\Phi_1$.

This can be summarized into the following SVAR(1):

$$\begin{pmatrix} \Theta & 0 \\ 0 & I \end{pmatrix} \begin{pmatrix} X_t \\ X_{t-1} \end{pmatrix} = \begin{pmatrix} \Lambda_1 & \Lambda_2 \\ I & 0 \end{pmatrix} \begin{pmatrix} X_{t-1} \\ X_{t-2} \end{pmatrix} + \begin{pmatrix} U_t \\ 0 \end{pmatrix},$$

or in matrix form:

$$\mathrm{T} Z_t = \Phi Z_{t-1} + E_t, \qquad (2)$$

with $\mathrm{T} = \begin{pmatrix} \Theta & 0 \\ 0 & I \end{pmatrix}$, $Z_t = \begin{pmatrix} X_t \\ X_{t-1} \end{pmatrix}$, $\Phi = \begin{pmatrix} \Lambda_1 & \Lambda_2 \\ I & 0 \end{pmatrix}$ and $E_t = \begin{pmatrix} U_t \\ 0 \end{pmatrix}$.

The corresponding reduced form VAR(1) is then:

$$Z_t = \Gamma Z_{t-1} + \nu_t, \qquad (3)$$

with $\Gamma = \mathrm{T}^{-1}\Phi$ and $\nu_t = \mathrm{T}^{-1} E_t$.

4.4.1.4. Identification of the structural model

The identification problem faced when trying to estimate equation *(1)* is illustrated with a SVAR(1) model. Let us consider the following SVAR(1), where the vector X_t contains five variables (N=5), as in the actual model:

$$\Theta X_t = \Phi X_{t-1} + U_t. \qquad (4)$$

Its corresponding reduced form is:

$$X_t = \Gamma X_{t-1} + V_t,$$

with $\Gamma = \Theta^{-1}\Phi$ and $V_t = \Theta^{-1} U_t$.

As the model includes five variables, the matrices Θ and Φ each contain N^2 = 25 elements, so we need to uncover 50 elements in total. However, by estimating the reduced form we only get 25 elements from Γ and N(N+1)/2 = 15 distinct elements from the variance covariance matrix Σ of the non-structural errors V_t ($\Sigma = E[V_t V_t'] = \Theta^{-1}\Theta^{-1}{}'$), for a total of 40 estimated elements. As a result, we are short of N(N-1)/2 = 10 elements that cannot be identified. As the number of unknown parameters exceeds the number of estimates by 10, we have to impose restrictions on 10 elements of the matrix Θ in order to identify its remaining 15 elements. We impose that 10 elements of Θ are nil such that this matrix becomes lower triangular. Given this specific ordering of variables, a given variable is contemporaneously affected by the ones that appear before in the vector X_t. These restrictions can be visualized by rewriting our model (given by equation *(4)*) with an explicit matrix Θ and vector X_t:

$$\begin{pmatrix} \theta_{11} & 0 & 0 & 0 & 0 \\ \theta_{21} & \theta_{22} & 0 & 0 & 0 \\ \theta_{31} & \theta_{32} & \theta_{33} & 0 & 0 \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} & 0 \\ \theta_{51} & \theta_{52} & \theta_{53} & \theta_{54} & \theta_{55} \end{pmatrix} \begin{pmatrix} P_t \\ I_t \\ Y_t \\ R_t \\ Q_t \end{pmatrix} = \Phi X_{t-1} + U_t.$$

The first selected variable, P_t, is the log of domestic commodity price indices of Australia, Canada, and New Zealand. This variable is assumed to be predetermined, as it is not contemporaneously influenced by any variable included in the model. In other words, we assume that each country's real GDP, CPI, real exchange rate and interest rates do not have contemporaneous effects (within one quarter considering our data frequency) on commodity prices. As the prices of commodities are often determined on the world market, it is reasonable to assume that they are not significantly affected at impact by the domestic variables of the relatively small and open economies we consider. Nevertheless, note that the selected model allows for commodity prices to be influenced by past values of all of the five considered variables.

The three variables representing domestic economic fundamentals that may influence exchange rates (first differences of the log CPI, I_t, log real GDP, Y_t, and real interest rates, R_t) are ordered according to their level of predetermination. Variables that are more dependent on other ones, i.e. less predetermined, are positioned later in the ordering. This is why real interest rates are placed after real GDP, itself placed after CPI. Lastly, as our primary interest is to analyse the exchange rate responses, the variable Q_t (log of the real exchange rates) is placed last, being the most endogenous variable as it is contemporaneously influenced by all other variables.

4.4.2. Direct and indirect effects of a commodity prices shock on the real exchange rate

4.4.2.1. Decomposing the real exchange rate response

The goal of this paper is to uncover the importance of two relations: the direct effect of commodity prices on real exchange rates and their indirect influence, through the macroeconomic fundamentals that, in turn, may influence real exchange rates. We consequently separate the exchange rate responses to a commodity prices shock into two effects. On the one hand, a direct effect reflecting the direct impact of commodity prices on real exchange rates, an impact that cannot be explained by the other variables incorporated in the model. On the other hand, an indirect effect reflecting the effect of fundamentals (CPI, real GDP and real interest rates) and past exchange rate responses on the current real exchange rate following a commodity prices shock. This decomposition is achieved by using an approach similar to that of Bachman and Sims (2012), which was introduced by Bernanke et al. (1998). In contrast to these previous studies, which focused on either the direct or the indirect effect of a shock of interest,[30] this paper is interested in both the direct and the indirect effects of a commodity prices shock.

[30] These two articles respectively focus on fiscal and monetary policy shocks.

This impulse response breakdown into two effects will become much clearer with an example. To develop some intuition, let us derive those responses with a simple SVAR(1) model (As we previously showed, any SVECM can be rewritten under that form). For illustration purposes, we assume that the model only includes three variables: the commodity prices, P_t, one fundamental that may influence exchange rates, the real GDP, Y_t, and the real exchange rates, Q_t. In this context, the structural model corresponds to:

$$\begin{pmatrix} \theta_{11} & 0 & 0 \\ \theta_{21} & \theta_{22} & 0 \\ \theta_{31} & \theta_{32} & \theta_{33} \end{pmatrix} \begin{pmatrix} P_t \\ Y_t \\ Q_t \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} & \phi_{13} \\ \phi_{21} & \phi_{22} & \phi_{23} \\ \phi_{31} & \phi_{32} & \phi_{33} \end{pmatrix} \begin{pmatrix} P_{t-1} \\ Y_{t-1} \\ Q_{t-1} \end{pmatrix} + \begin{pmatrix} U_{Pt} \\ U_{Yt} \\ U_{Qt} \end{pmatrix}.$$

This can be rewritten in the more compact form:

$$\Theta X_t = \Phi X_{t-1} + U_t, \tag{5}$$

with the corresponding reduced form VAR(1):

$$X_t = \Gamma X_{t-1} + V_t. \tag{6}$$

Applying recursive substitution on the VAR(1) described by equation *(6)*, we obtain:

$$X_t = V_t + \Gamma V_{t-1} + \Gamma^2 V_{t-2} + \ldots + \Gamma^t V_0, \tag{7}$$
$$X_t = \Theta^{-1} U_t + \Gamma \Theta^{-1} U_{t-1} + \Gamma^2 \Theta^{-1} U_{t-2} + \ldots + \Gamma^t \Theta^{-1} V_0.$$

From equation *(7)*, we can derive impulse responses, i.e. the reactions of the three variables to shocks in commodity prices, GDP, and exchange rate. As it is the focus of this paper, we concentrate on the exchange rate responses to commodity prices shocks.

Contemporaneous responses can be analytically derived when the model is identified and estimated, providing us with the matrices Θ and Φ. First, we can compute the exchange rate response to a contemporaneous commodity prices shock. From equation *(5)*, the real exchange rate Q_t is defined as follows:

$$\theta_{33} Q_t = -\theta_{31} P_t - \theta_{32} Y_t + \phi_{31} P_{t-1} + \phi_{32} Y_{t-1} + \phi_{33} Q_{t-1} + U_{Qt}. \tag{8}$$

However, the shock we are interested in is contemporaneous. In this context the $_{t-1}$ terms do not have any effect. For illustration purposes, these terms are set to zero, equation *(8)* thus becomes:

$$\theta_{33}Q_t = -\theta_{31}P_t - \theta_{32}Y_t + U_{Qt},$$

$$\frac{\partial Q_t}{\partial U_{Pt}} = \left(-\frac{\theta_{31}}{\theta_{33}} \times \frac{\partial P_t}{\partial U_{Pt}}\right) + \left(-\frac{\theta_{32}}{\theta_{33}} \times \frac{\partial Y_t}{\partial U_{Pt}}\right) + \frac{1}{\theta_{33}} \times \frac{\partial U_{Qt}}{\partial U_{Pt}}. \qquad (9)$$

First, note that as the structural errors are orthogonal, a commodity prices shock does not affect U_{Qt}. We can then see from *(9)* that the contemporaneous exchange rate response to a commodity prices shock then depends on two effects. A direct one depending on the variations of commodity prices only, the first term in parentheses in *(9)*, and an indirect one depending on the commodity prices effect on fundamental variables, such as the real GDP Y_t in this example. This indirect effect is described by the second term in parentheses.

However, in order to fully compute $\frac{\partial Q_t}{\partial U_{Pt}}$ equations for Y_t and P_t have to be extracted from the structural model given by *(5)*, still only considering contemporaneous terms:

$$\theta_{22}Y_t = -\theta_{21}P_t + U_{Yt} \text{ and } \theta_{11}P_t = U_{Pt},$$

which yields:

$$\theta_{22}Y_t = -\frac{\theta_{21}}{\theta_{11}}U_{Pt} + U_{Yt}.$$

We can now substitute P_t and Y_t into *(8)*:

$$\theta_{33}Q_t = -\frac{\theta_{31}}{\theta_{11}}U_{Pt} + \frac{\theta_{32}\theta_{21}}{\theta_{22}\theta_{11}}U_{Pt} - \theta_{32}U_{Yt} + U_{Qt}.$$

The total exchange rate response to a commodity prices shock is then given by:

$$\frac{\partial Q_t}{\partial U_{Pt}} = \frac{\theta_{21}\theta_{32} - \theta_{22}\theta_{31}}{\theta_{11}\theta_{22}\theta_{33}} = \left(-\frac{\theta_{22}\theta_{31}}{\theta_{11}\theta_{22}\theta_{33}}\right) + \left(\frac{\theta_{21}\theta_{32}}{\theta_{11}\theta_{22}\theta_{33}}\right).$$

Once again the first term in parentheses represent the direct effect, and the second one the indirect effect.

Going back to the recursive representation given by *(7)*, we can actually compute all contemporaneous responses in a simpler way, as:

$$\frac{\partial X_t}{\partial U_t} = \frac{\partial V_t}{\partial U_t} = \Theta^{-1} = \begin{pmatrix} \theta_{11}^{\ -1} & 0 & 0 \\ -\dfrac{\theta_{21}}{\theta_{11}\theta_{22}} & \theta_{22}^{\ -1} & 0 \\ \dfrac{\theta_{21}\theta_{32} - \theta_{22}\theta_{31}}{\theta_{11}\theta_{22}\theta_{33}} & -\dfrac{\theta_{32}}{\theta_{22}\theta_{33}} & \theta_{33}^{\ -1} \end{pmatrix}. \qquad (10)$$

The exchange rate response to a commodity prices shock, derived earlier, is given by the (3,1) element of the matrix Θ^{-1} given by (10).

We can also calculate the dynamic impulse responses, i.e. responses over several periods, using the same approach at any desired time horizon. The only difference with dynamic responses is that they also depend on previously computed responses. For instance, the exchange rate response to a commodity prices shock that occurred one period ago depends on the contemporaneous responses contained in the matrix Θ^{-1}. Considering the structural exchange rate equation *(8)*, and rewriting it one period after *t*, we have:

$$\theta_{33}Q_{t+1} = -\theta_{31}P_{t+1} - \theta_{32}Y_{t+1} + \phi_{31}P_t + \phi_{32}Y_t + \phi_{33}Q_t + U_{Qt+1},$$

$$\frac{\partial Q_{t+1}}{\partial U_{Pt}} = \frac{1}{\theta_{33}}\left(-\theta_{31}\frac{\partial P_{t+1}}{\partial U_{Pt}} - \theta_{32}\frac{\partial Y_{t+1}}{\partial U_{Pt}} + \phi_{31}\frac{\partial P_t}{\partial U_{Pt}} + \phi_{32}\frac{\partial Y_t}{\partial U_{Pt}} + \phi_{33}\frac{\partial Q_t}{\partial U_{Pt}} + \frac{\partial U_{Qt+1}}{\partial U_{Pt}} \right),$$

$$\frac{\partial Q_{t+1}}{\partial U_{Pt}} = \left(-\frac{\theta_{31}}{\theta_{33}} \times \frac{\partial P_{t+1}}{\partial U_{Pt}} + \frac{\phi_{31}}{\theta_{33}} \times \frac{\partial P_t}{\partial U_{Pt}} \right) + \left(-\frac{\theta_{32}}{\theta_{33}} \times \frac{\partial Y_{t+1}}{\partial U_{Pt}} + \frac{\phi_{32}}{\theta_{33}} \times \frac{\partial Y_t}{\partial U_{Pt}} \right) + \left(\frac{\phi_{33}}{\theta_{33}} \times \frac{\partial Q_t}{\partial U_{Pt}} \right). \quad (11)$$

First, notice that the term $\frac{\partial U_{Qt+1}}{\partial U_{Pt}}$ is nil as structural innovations are orthogonal and serially uncorrelated. As Q_t is contemporaneously influenced by all the other variables, the dynamic responses of that variable, i.e. one or several periods after the U_{Pt} shock, depend on other dynamics responses, $\frac{\partial P_{t+1}}{\partial U_{Pt}}$ and $\frac{\partial Y_{t+1}}{\partial U_{Pt}}$, as well as on the contemporaneous responses computed earlier in *(10)* : $\frac{\partial P_t}{\partial U_{Pt}}$, $\frac{\partial Y_t}{\partial U_{Pt}}$ and $\frac{\partial Q_t}{\partial U_{Pt}}$. Consequently, $\frac{\partial Q_{t+1}}{\partial U_{Pt}}$ has an additional component compared to contemporaneous responses, as the indirect effect now includes past exchange rate responses. The direct effect, resulting solely from commodity prices movements is represented by the first term in parentheses in *(11)*. The indirect effect now results from the commodity prices effect on the exchange rate through real GDP (second term in parentheses) and from the past exchange rate responses (third term in parentheses). As it is the case for contemporaneous responses, dynamic responses can be easily computed once the model is identified: given equation *(7)*, we know that the impulse response matrix one period after a shock on U_t occur is given by $\Gamma\Theta^{-1} = \Theta^{-1}\Phi\Theta^{-1}$.

The decomposition of the exchange rate responses is subsequently implemented in two steps. First, by separating the direct and indirect effects. Then, by decomposing the indirect effect in terms of each variable it is made of, i.e. all selected variables except commodity prices. Considering equation *(11)*, this second step involves separating the second and third terms in parentheses. The method presented above can then be used for any time horizon or lag structure. The actual model includes two additional variables, the CPI and real interest rates. Consequently, the indirect effect depends on CPI, real GDP, real interest rates, and past real exchange rates.

4.4.2.2. Economic interpretation of the effects derived from the exchange rate response

In the model, the direct effect of a commodity prices shock can have several interpretations. First, it represents the part of the real exchange rate movements that are not attributable to the other variables included in the model. In this sense it may capture some speculative demand for currencies, i.e. demand that is unrelated to fundamentals. This interpretation is likely valid for commodity currencies, as their link to commodity prices can be used as an investment strategy. Second, this direct effect also includes variations related to other variables that could influence real exchange rates but that are not domestic fundamentals, e.g., the Chinese or American demand for commodities, changes in foreign monetary policy and many others. Consequently, the direct effect accounts for the speculative demand for commodity currencies, and possibly for the exchange rate effect of foreign fundamental variables.

The indirect components have a more clear-cut interpretation. The CPI, real GDP, and real interest rate components each reflect the variation in real exchange rates that can be attributed to the reaction of these three variables in response to a commodity prices shock. The last indirect component, which depends on past exchange rate responses to the initial commodity prices shock, can be interpreted as reflecting the persistence of exchange rates variations in response to the shock of interest.

4.4.3. Estimation Procedure

4.4.3.1. Lag structure selection

Several information criteria and tests are used to determine the number of lags (p) to include in the VAR form of the model. As a SVECM(p) can be rewritten as a VAR(p+1), the SVECM includes one lag fewer than indicated by the VAR criteria. The results for the lag structure indicators are available for each sample in appendix C. Four lags are selected for Australia and Canada, following the indicator that indicated the greater number of lags, which in these two cases are those associated with the likelihood ratio test. However, as far as New Zealand is concerned, the various tests and criteria pointed toward different lag structures. As a compromise, five lags are included in the VAR model for this country.

4.4.3.2. Estimation method

The reduced form model (VECM) is estimated following the Johansen reduced rank procedure,[31] a one-step approach with maximum likelihood that was previously used for the Johansen tests described in the notes to appendix D.1. As defined in the cointegration tests (section 3.4.), the cointegration relations do not include a constant, so as not to be redundant with the vector of constants included in the VECM. The cointegration relations identified with the Johansen tests are not imposed before estimation, however, the number of such relation(s) for each country is.

The structural form of the model, as described by *(12)* in appendix E, is estimated with maximum likelihood and an iterative procedure that uses the scoring algorithm defined in Amisano and Giannini (1997).

4.4.3.3. Confidence intervals of the impulse responses

The confidence intervals for impulse responses are percentile intervals, as they are based on an empirical distribution of impulse responses. Two levels of confidence are presented along with the impulse responses. First, a restrictive one, at the 95% level. Second, a less strict one at the 68% level, which corresponds to the percentage of values that lie within one standard deviation of the mean in a normal distribution.

Confidence intervals are bootstrapped following the method of Efron and Tibshirani (1993). This bootstrap process starts by rewriting the SVECM under its underlying VAR form. The VAR form is then estimated and its residuals collected. These residuals are subsequently

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[31] Both the structural and the reduced form models were estimated using the time series analysis software JMulTi. For more information, see Lütkepohl and Krätzig (2004).

drawn randomly with replacement to obtain bootstrap residuals. Bootstrap values of the time series originally included in the model are then created using the bootstrap residuals, estimates of the original model and pre-sample values, the values excluded from the estimation due to the chosen lag structure. Finally, the VAR model is estimated using the bootstrap time series, and impulse responses are computed using *(7)*, up to a given time horizon. This procedure is then repeated a large number of times. In order to obtain stable distributions of impulse responses, thus reliable confidence intervals, the number of bootstrap replications is set to 3000.

Using this method, the percentile confidence intervals are based on the empirical distribution of the various bootstrap responses and are defined as follows:

$$CI_P = \lfloor P_{\alpha/2}, P_{1-(\alpha/2)} \rfloor$$

For instance, with a confidence level of 95%, α = 0.05, so $P_{\alpha/2}$ represents the 0.025 percentile of the impulse response distribution at a given horizon, and $P_{1-(\alpha/2)}$ the 0.975 percentile.

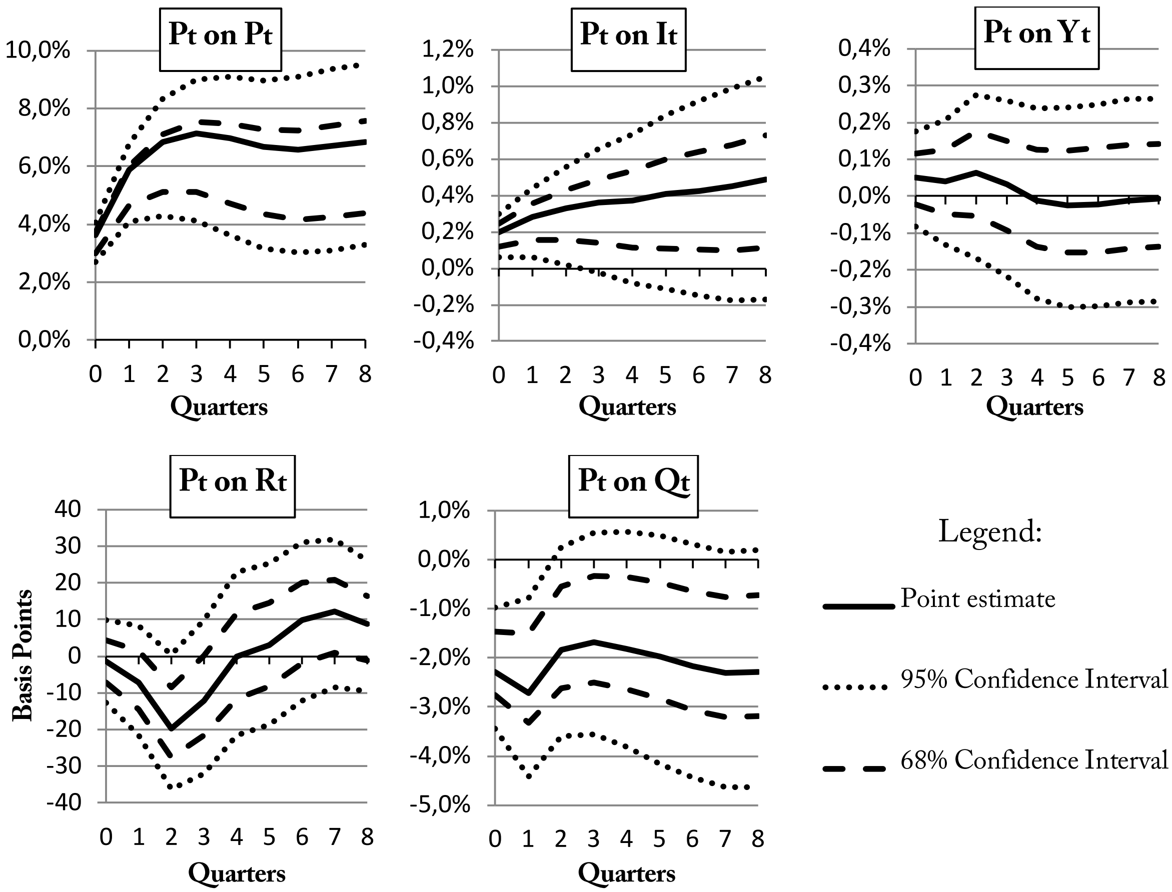
4.4.4. Empirical results

The estimation of the SVECM for each country is presented in the following pages through impulse responses analysis. Estimates of the contemporaneous interactions and cointegration relations are available in appendix E. For each country, the model includes the following variables: the domestic commodity prices index, the CPI, the real GDP, the real interest rates, and the real exchange rate vis-à-vis the US dollar.

Three types of results are described. First, the effect of a positive commodity prices shock (i.e. an unexpected increase in commodity prices) on the variables included in the model. Second, the decomposition of the real exchange rate responses to a commodity prices shock into its direct and indirect effects. Third, the decomposition of the indirect effect itself into its four components. The impulse responses are computed at a horizon of two years, or eight quarters.

4.4.4.1. Australia

Figure 4. Commodity prices effect on Australian fundamentals and real exchange rate, 1982Q1 – 2012Q4.

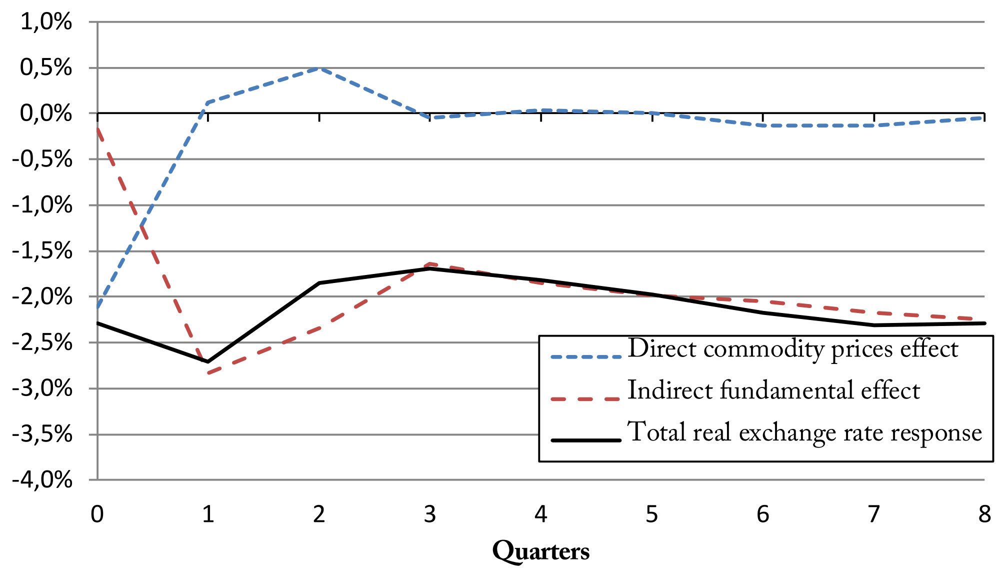


Notes. This type of graph represents the effect of a commodity prices shock on the levels (as opposed to the growth rates) of the five variables included in the SVECM, which are all logged except the real interest rates. Consequently, the responses to a commodity prices movement of one standard deviation are presented in percentage terms, apart from the real interest rates for which the response is presented in absolute terms with basis points (bp). The SVECM includes the following variables, with their corresponding abbreviations in brackets: the log of the domestic commodity prices index (Pt), the log of the Consumer Price Index (It), the log of the real GDP (Yt), the real interest rates (Rt), and the log of the real exchange rate vis-à-vis the US dollar (Qt). The response of each variable to a commodity prices shock is computed using the VAR form of the SVECM as explained in section 4.4.2.1. The confidence intervals are bootstrapped following the standard procedure described in section 4.4.4.3.

Three variables are significantly influenced by domestic commodity prices in Australia. As showed by the "Pt on Qt" graph, at the 95% confidence level, the commodity prices effect on real exchange rates is significant in the short run, instantaneously and after one quarter. If the more permissive confidence interval of 68% is considered then the real exchange rate appears permanently influenced by a commodity prices shock. The findings of the commodity currency literature are thus confirmed for the Australian dollar when using a domestic index in nominal terms, instead of an index in real terms as in Chen and Rogoff (2003). CPI increases with commodity prices up to three quarters after the initial commodity prices shock, at the 95% confidence level. The effect on interest rates is not instantaneous, as it takes two quarters for the shock to significantly reduce real interest rates. This effect is probably the result of the higher prices triggered by a positive commodity price shock, which then reduces interest rates once adjusted for price increases. However, real GDP is not affected by domestic commodity prices in the data. One explanation could be that, though commodity exports have represented over half of Australia's total exports in recent years, the country's higher revenues from commodity exports also triggered an increase in imports, making the net commodity effect on real GDP ambiguous.

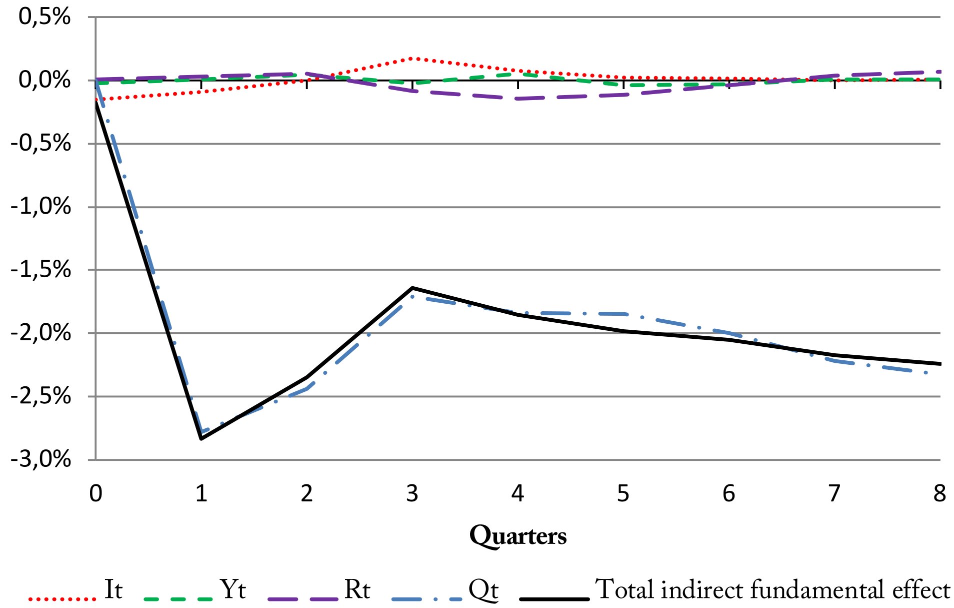
Figures 5.a and 5.b. Decomposition of real exchange rate responses to a commodity prices shock, Australia, 1982Q1 – 2012Q4.

Figure 5. a. Direct commodity prices effect, indirect fundamental effect and total real exchange rate response to a commodity prices shock, Australia, 1982Q1 – 2012Q4.



Notes. This graph presents the decomposition of the real exchange response to a domestic commodity prices shock into two components. First, a direct effect that solely depends on changes in commodity prices. Second, an indirect effect that reflects the commodity prices influence on CPI, real GDP, real interest rates, and past real exchange rates. The total real exchange rate response equals the sum of these two effects. A detailed example of this decomposition is provided in section 4.4.2.1.

Figure 5. b. Consumer Price Index (It), Real GDP (Yt), Real Interest Rates (Rt) and Real Exchange Rates (Qt) components of the indirect effect of a commodity prices shock, Australia, 1982Q1 – 2012Q4.



Notes. This last type of graph illustrates the decomposition of the indirect fundamental effect showed in previous figures. Its four components depend on the respective effect of a domestic commodity prices shock on CPI (It line), real GDP (Yt line), real interest rates (Rt line) and past real exchange rates (Qt line). Detailed computation is exposed in section 4.4.2.1.

Figure 5.a. shows that the contribution of the indirect effect to the total exchange rate response is always negative, meaning that the commodity prices effect on the selected fundamentals also contributes to the real exchange rate appreciation triggered by higher commodity prices. The direct effect becomes positive after a quarter but its magnitude is lower, becoming almost nil after a year. However, it is interesting to note that, contemporaneously, the direct effect explains almost completely the total exchange rate response. As the selected fundamentals can be sticky in the short run (with the exception of real interest rates), one can assume that the direct effect captures expectations about future exchange rate and fundamental movements. As the effects of higher commodity prices on macroeconomic fundamentals can take months to effectively come into effect, agents

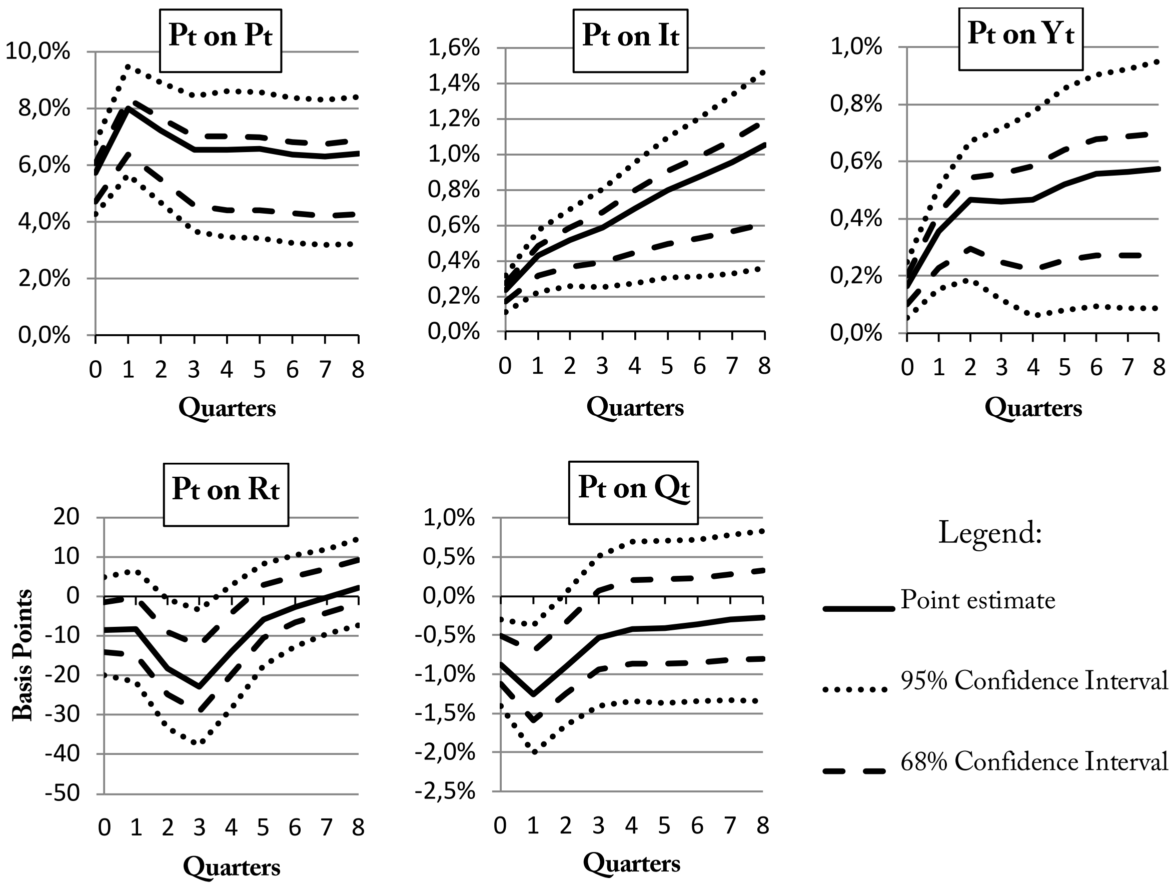
anticipating these effects can have an instantaneous influence on exchange rates by buying the considered currency based solely on an increase in commodity prices. This is exactly what the direct speculative effect captures in our exchange rate response decomposition.

From one quarter after the shock and onwards, the contributions reverse: the total exchange rate response is almost entirely explained by the indirect effect, which is intuitively more sustainable than the direct effect as it is backed by fundamental changes in the domestic economy. After this reversal, the exchange rate response is no longer significant at the 5% level and is dominated by the indirect effect. Overall, as the direct speculative effect shows little persistence beyond a quarter after the commodity prices shock, one may conclude that the link between the Australian dollar and commodity prices is justified by the effect of commodities on the domestic economy.

The breakdown of the indirect effect into its four components (CPI, real GDP, real interest rates, and past real exchange rates) confirms the weak link between fundamentals and exchange rates suggested by the exchange rate disconnect puzzle. Considering **Figure 5.b.**, the contributions of real interest rates (Rt) and especially real GDP (Yt) are negligible, though the effect of CPI (It) is more pronounced in the short run. Consequently, the indirect exchange rate response to a commodity prices shock is dominated at any period after the shock by past exchange rate responses, which are identified by the third component in *(11)*. At the time of the shock, this component is absent, as no lagged responses exist yet, which is why the total indirect effect is almost nil. After the initial shock, the past exchange rate response component comes into play, reflecting the significant impact of commodity prices on real exchange rates showed in the impulse responses. Eventually, as these effects become more and more lagged, the real exchange rate component, and with it, the whole indirect fundamental effect, die out from quarter four and onwards.

4.4.4.2. Canada

Figure 6. Commodity prices effect on Canadian fundamentals and real exchange rate, 1972Q1 - 2012Q4

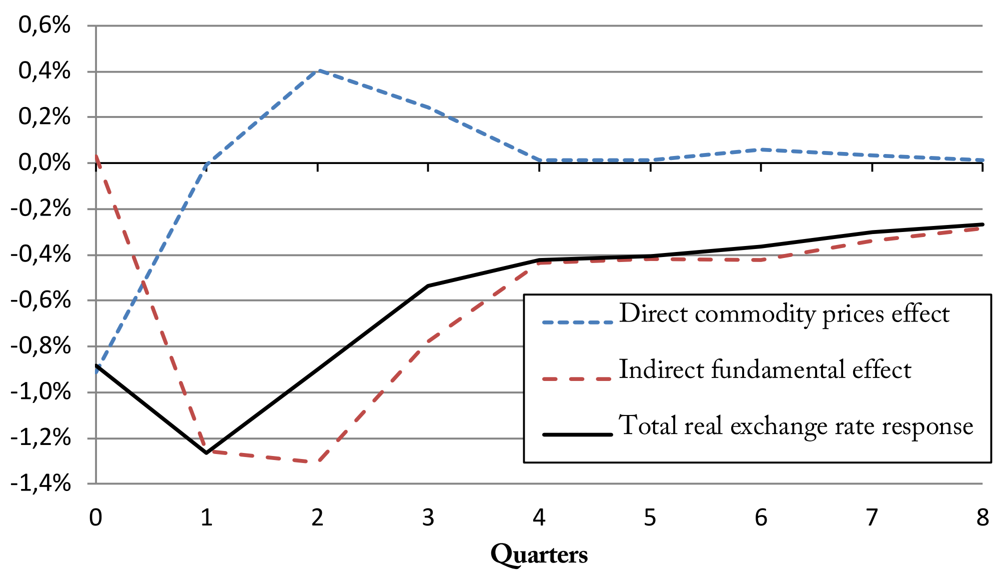


Notes. See **Figure 4.**

The findings of the commodity currency literature are also confirmed for Canada using domestic nominal commodity prices, though only in the short run. The exchange rate response is significant at the time of the shock as well as one quarter later at the 95% confidence level, and up to two quarters later at the 90% confidence level (90% confidence intervals were computed but are not presented for presentation purposes). As expected, commodity prices significantly increase CPI in the long-run, as the CPI response computed from the SVECM is permanently significant at the 95% confidence level. The real GDP is also permanently and positively influenced by commodity prices in Canada, at the 95% confidence level. As exports in Canada are less dependent on commodities than in Australia, one can assume that this positive effect on real GDP is mostly due to increases in investment following higher commodity prices. Finally, as in the case of Australia, commodity prices affect real interest rates with a lag of three quarters at the 95% confidence level (see the "Pt on Rt" graph on the previous page). These results differ from those of Cologni and Manera (2008), in a paper dedicated to the effect of oil prices on nominal interest rates in the G-7 economies. This implies that nominal and real interest rates can have different behaviours following a shock in commodity prices.

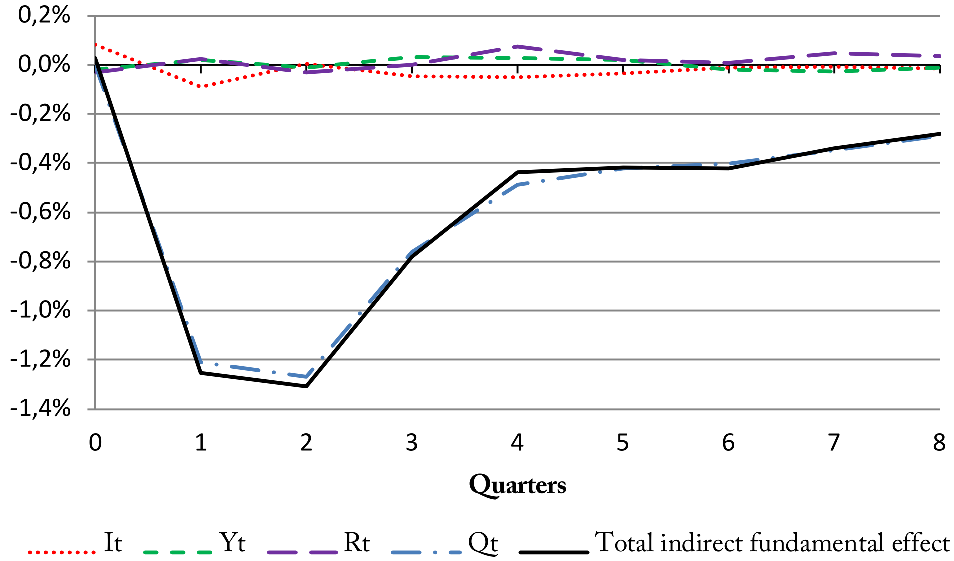
Figures 7.a and 7.b. Decomposition of the real exchange rate response to a commodity prices shock, Canada, 1972Q1 - 2012Q4

Figure 7. a. Direct commodity prices effect, indirect fundamental effect and total real exchange rate response to a commodity prices shock, Canada, 1972Q1 - 2012Q4



Notes. See **Figure 5.a.**

Figure 7. b. Consumer Price Index (It), Real GDP (Yt), Real Interest Rates (Rt) and Real Exchange Rates (Qt) components of the indirect effect of a commodity prices shock, Canada, 1972Q1 - 2012Q4



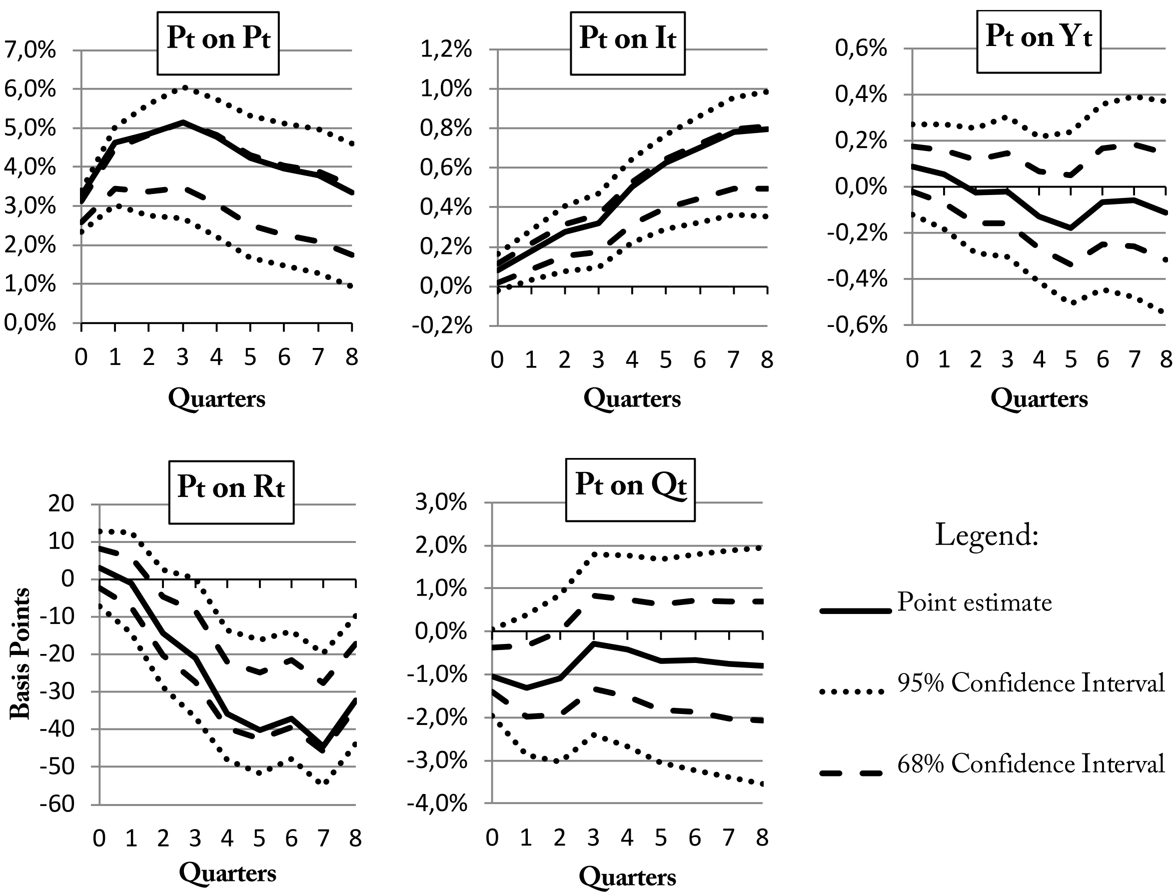
Notes. See **Figure 5.b.**

The responses of the real Australian and Canadian dollar exchange rates to a domestic commodity prices shock exhibit a certain similarity. In both cases, the contributions of the direct and indirect effects reverse between the time of the shock and one quarter after, with the direct one dominating at impact and the indirect one being more substantial later on. Yet, the indirect effect is more pronounced in the case of Australia, as it is reaches its peak in absolute value two quarters after the shock. At that time, the impact on the total response is reduced by a positive direct effect, i.e. the direct effect limits the real appreciation partly induced by fundamentals. In this context the direct effect may be interpreted as expectations that the initial real appreciation was actually an over appreciation that is too large to last. The total exchange rate response is stable after four quarters, although it ceases to be significant at the 68% confidence level from three quarters after the shock and onwards.

As it is the case for Australia, the indirect effect is dominated by past exchange rate responses at any period after the initial commodity prices shock, as showed in **Figure 7.b**. The real interest rates (Rt) and CPI (It) also appear more responsive following the shock than real GDP, confirming the impulse responses analysis. The indirect effect starts to decrease in magnitude after two quarters, which explains the insignficance of the total exchange response at the 95% confidence level from this point and onwards.

4.4.4.3. New Zealand

Figure 8. Commodity prices effect on New Zealand fundamentals and real exchange rate, 1986 Q1 – 2012 Q3:



Notes. See **Figure 4.**

Interestingly, domestic commodity prices do not influence the New-Zealand real exchange rate at the 95% confidence level, although they do at the 90% level. The findings of the commodity currency literature thus do not appear as robust as expected for the New Zealand dollar. This may arise from the composition of commodities in New Zealand: as they mostly include food items, they are not major components of global commodity indices. The difference between the results of the commodity currency literature and ours suggests that the New Zealand dollar is more driven by global commodity prices than by New Zealand's own commodities, which would confirm the importance of speculative demand for commodity currencies. This hypothesis is tested, by re-estimating the SVECM model for New Zealand with the IMF primary commodity prices index rather than the domestic ANZ Bank index.[32] The results indicate that the real New Zealand exchange rate responds to a world commodity prices shock instantaneously and after one quarter, at the 95% confidence level (the impact of world commodity prices on New Zealand variables is briefly presented through impulse responses in appendix F). This suggests that the commodity currency trade, by which one buys a currency that is expected to appreciate following higher commodity prices, is more pronounced in New Zealand than in Australia or Canada.

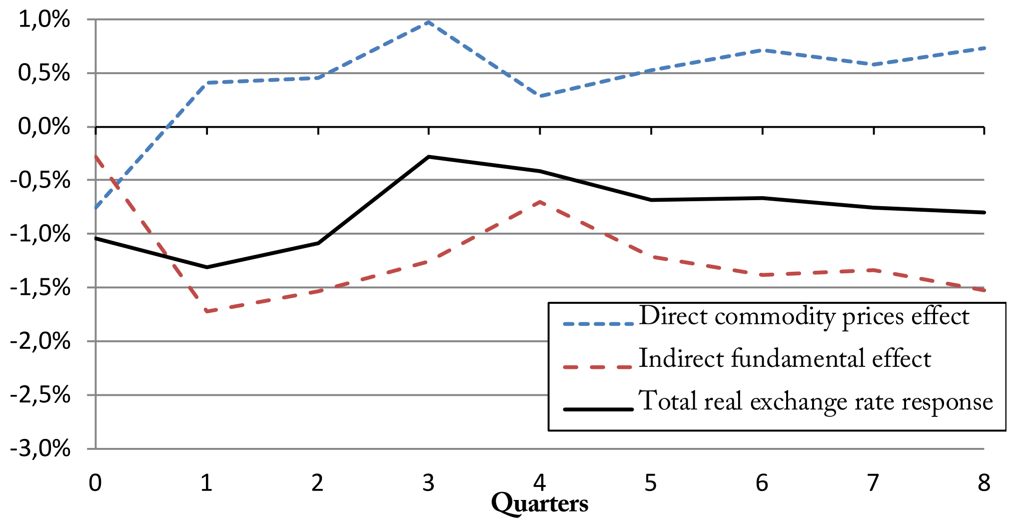
Going back to a domestic commodity prices shock, the New Zealand CPI is positively and permanently affected from one quarter after the shock and onwards. As it is the case for Australia, domestic commodity prices do not affect the real GDP but they negatively affect real interest rates, an influence that is probably due to the strong effect that commodity prices have on the CPI.

As it is the case for Australia and Canada, the following decomposition of the real exchange rate response is implemented considering a domestic commodity prices shock.

[32] As the index starts in 1992, it was reconstituted from 1986Q1 to 1991Q4, using its two main components, equally weighted: industrial input prices (comprising agricultural and metal prices) and oil prices (an average of the WTI, Brent and Dubai Fateh prices).

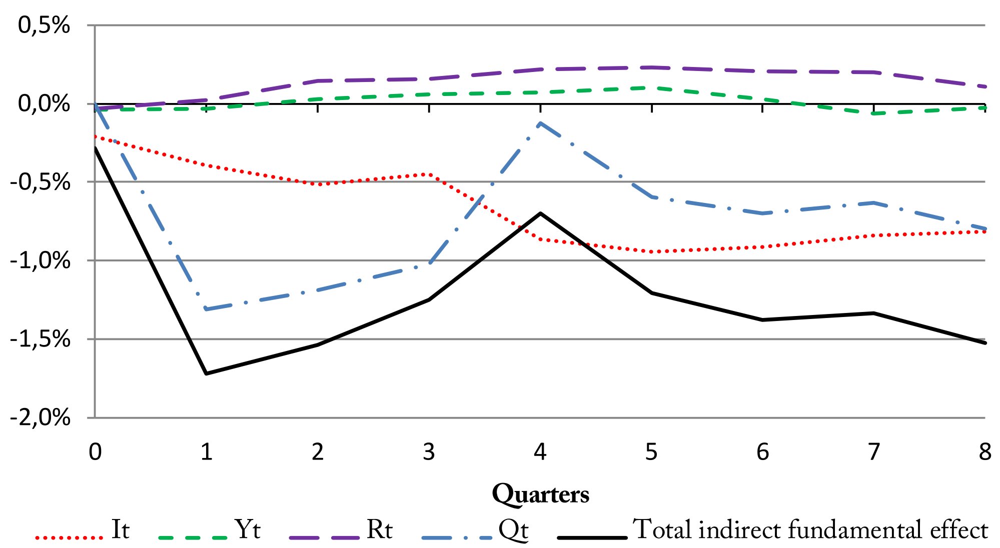
Figures 9.a and 9.b. Decomposition of the real exchange rate response to a commodity prices shock, New Zealand, 1986Q1 - 2012Q3

Figure 9. a. Direct commodity prices effect, indirect fundamental effect and total real exchange rate response to a commodity prices shock, New Zealand, 1986Q1 - 2012Q3



Notes. See **Figure 5.a.**

Figure 9. b. Consumer Price Index (It), Real GDP (Yt), Real Interest Rates (Rt) and Real Exchange Rates (Qt) components of the indirect effect of a commodity prices shock, New Zealand, 1986Q1 - 2012Q3



Notes. See **Figure 5.b.**

The direct and indirect effects appear different from those of Australia and Canada. At impact, both effects are quite weak in magnitude, which explains why the response is not initially significant at the 95% confidence level. Another difference comes from the persistence of the direct effect that is different from zero two years after the shock, whereas it dies out after a year in the case of Australia and Canada. This seems to show that the New Zealand dollar is more subject to speculative demand than its Australian and Canadian counterparts, as it was suggested by the exchange rate response to world commodity prices. Yet, as in previous cases, the direct effect is initially stronger but becomes dominated by the indirect effect from one quarter after the shock.

Contrary to Australia and Canada, the indirect effect is not only driven by past exchange rate responses (Qt). It is also significantly influenced by the CPI (It), which in part reflects the permanent influence of commodity prices on the general prices level in New Zealand, as showed in **Figure 8**. This suggests that the higher prices triggered by an unexpected increase in commodity prices in turn appreciates the New Zealand real exchange rate, which is consistent with the expected change in real exchange rates after a domestic price increase, ceteris paribus.

4.5. Robustness analysis using Canadian monthly data

4.5.1. Differences from the quarterly data

Two types of robustness tests are conducted using monthly data for Canada. First, we consider two subsamples that exhibit different commodity prices volatility. Second, we replace real GDP with the trade balance (in value) in the SVECM estimation, which is a way of testing the influence of net exports as a transmission channel between commodity prices and commodity currencies. Additionally, for this second robustness test, real exchange rates are expressed as month-end values, instead of monthly averages in other samples.

4.5.2. Robustness test using industrial production and dividing the data into two subsamples.

As for our first robustness test, a real GDP proxy had to be selected as GDP figures are not available on a monthly basis. Consequently, real monthly GDP in Canada is approximated by the country's Industrial Production (IP), which takes well into account the production of goods and commodities. The Canadian monthly data appears very close to its quarterly alternative, so trends identified earlier concerning the different interactions between variables remain valid. The industrial production evolution is similar to that of real GDP. Hence, we do not expect the results to be materially affected by this different measure of real economic activity.[33]

Moreover, it appears that we can roughly divide the evolution of the monthly Canadian domestic commodity prices index (BCPI) into two distinct periods. A period of relatively low volatility stretches from 1972 to 1998, despite an important rise from 1972 to 1980. The

[33] Using a quarterly average of industrial production over the 1972 – 2012 period, the correlation between real GDP and industrial production in Canada is 0.995.

second period, from 1999 to 2012, shows increased volatility: the index triples in value from early 2003 to mid-2008, before being more than halved during the second half of 2008. With a monthly data frequency, the number of observations in each period is high enough to allow for a separate study the of commodity prices impact.

4.5.2.1. Unit root tests

The Canadian monthly data is studied throughout two distinct periods. First, from January 1972, when the BCPI series were initiated, to December 1998. The second period spans from January 1999 to October 2012, when the most recent data was available for all the selected variables. The results of the tests are presented in details in appendix B.2.

In the first sub-period, the BCPI does not exhibit a unit root. It is, however, included in the SVECM as its first difference, which does not exhibit a unit root either. Consequently, the resulting estimates are not biased. The ADF tests are robust to shorter lag structures, such as the ones designated by the BIC that indicates a maximum of four lags.

In the second sub-period, all the variables appear to contain a unit root. Accordingly, all of the variables are included as their first difference in the SVECM.

4.5.2.2. Cointegration tests

As with the quarterly sample, for each subsample using a monthly frequency, the Canadian data contains one cointegration relation. The details of the Johansen test for the two monthly sub-samples are available in appendix D.2.

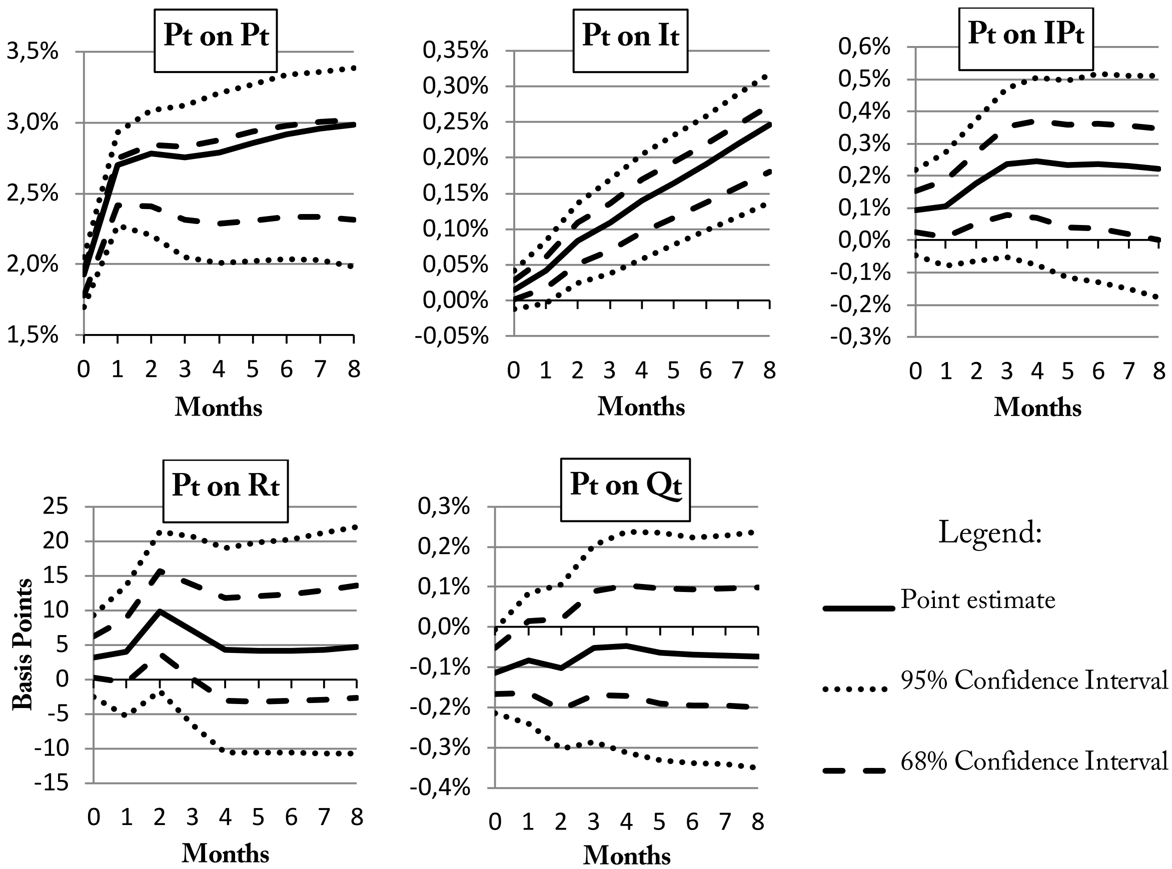
4.5.2.3. Overview of the results with two subsamples

Although, in theory, impulse responses computed with monthly or quarterly data should reach a stable level after the same amount of time, the responses stabilized over an 8-month horizon using monthly samples, which is shorter than the 8-quarter period selected for quarterly data. The following responses are thus presented over an 8-month period as responses hardly change eight months after the commodity prices shock and onwards. The abbreviations included in the following graphs are identical to the ones used for quarterly data, with the exception of Industrial Production (IPt) that replaces the real GDP (Yt).

The change of frequency, from quarterly to monthly data, did not significantly alter the results, apart from the responses of interest rates that appear widely different depending on the period that is considered. Additionally, the direct and indirect effects do not really differ between the two subsamples, although the impulse responses show the greater impact of a commodity prices shock in a period of high commodity prices volatility.

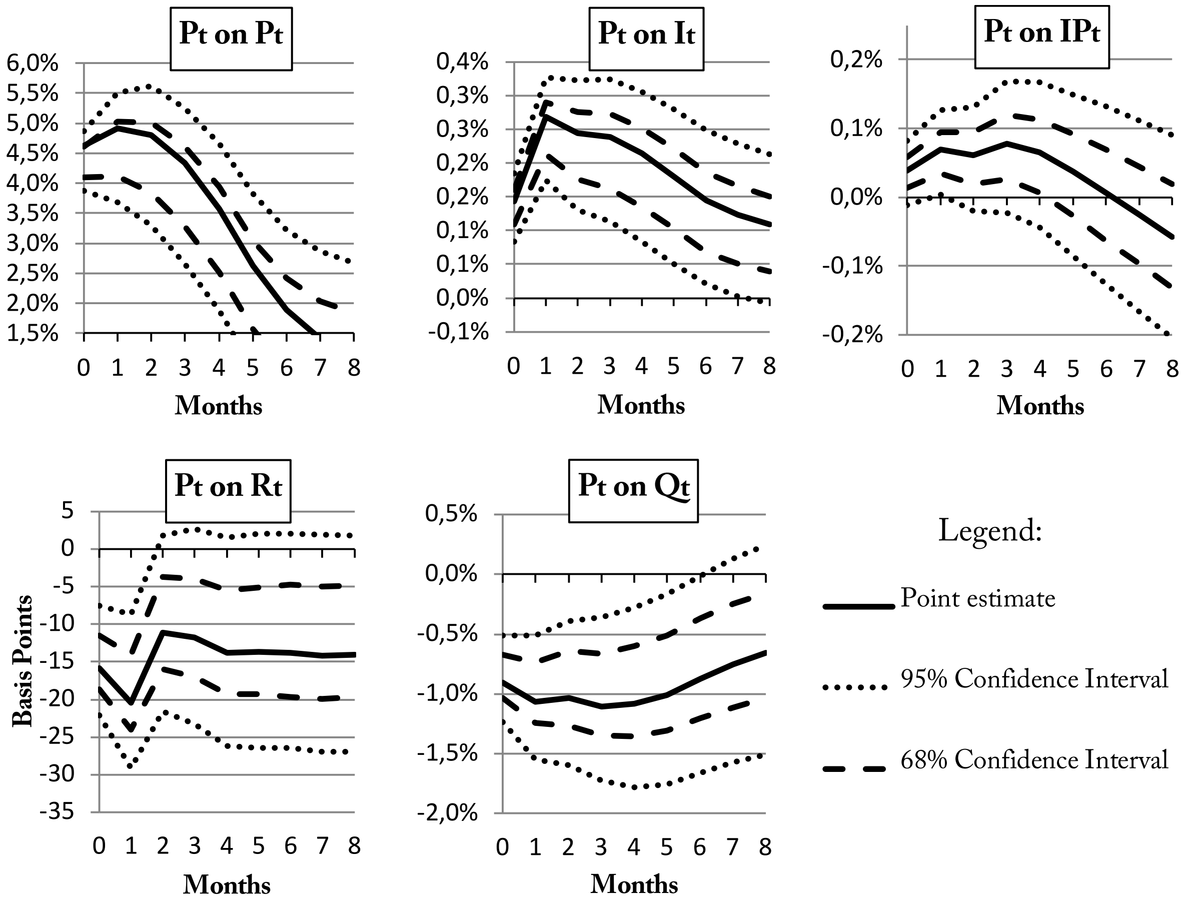
4.5.2.4. Impulse responses to a domestic commodity prices shock

Figure 10. Commodity prices effect on Canadian fundamentals and real exchange rate, 1972 M1 – 1998 M12 subsample



Notes. See **Figure 4.**

Figure 11. Commodity prices effect on Canadian fundamentals and real exchange rate, 1999 M1 – 2012 M10 subsample



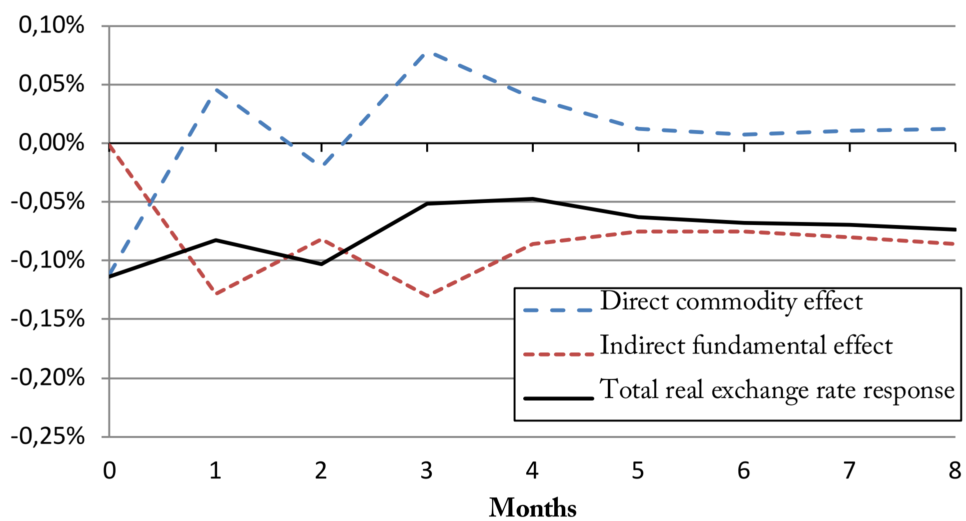
Notes. See **Figure 4.**

As the first subsample represents a period of relatively low volatility for Canadian commodities (see **Figure 2**), a weaker commodity prices impact is expected. Indeed, although the response of the real exchange rate is statistically significant at the 95% level of confidence, its magnitude is almost ten times lower than during the 1999 – 2012 period (**Figure 10** shows a real appreciation of approximately 0.1%, versus 1% in **Figure 11**). During the low volatility period, the Canadian CPI is permanently affected as it is the case with quarterly data. At the 68% level of confidence, the industrial production is affected for eight months, while the overall influence on real interest rates is significant only two months after the shock.

Considering the second subsample, all the variables respond at the 95% level to a commodity prices shock. The effect is stronger for the real exchange rate as it remains significant for six months. Contrary to the first subsample, the CPI is no longer permanently affected by the shock, though the effect is still significant for seven months. It is weaker for the industrial production that is only affected one month after the initial shock. Finally, real interest rates are affected for two months at the 95% level and permanently at the 68% level, in contrast with the previous subsample. These results suggest that there is a complex and changing relation between commodity prices and real interest rates. However, unlike the case of New Zealand, the strong responses of CPI or real interest rates do not translate into significant indirect effects as we will see in figures 14 and 15.

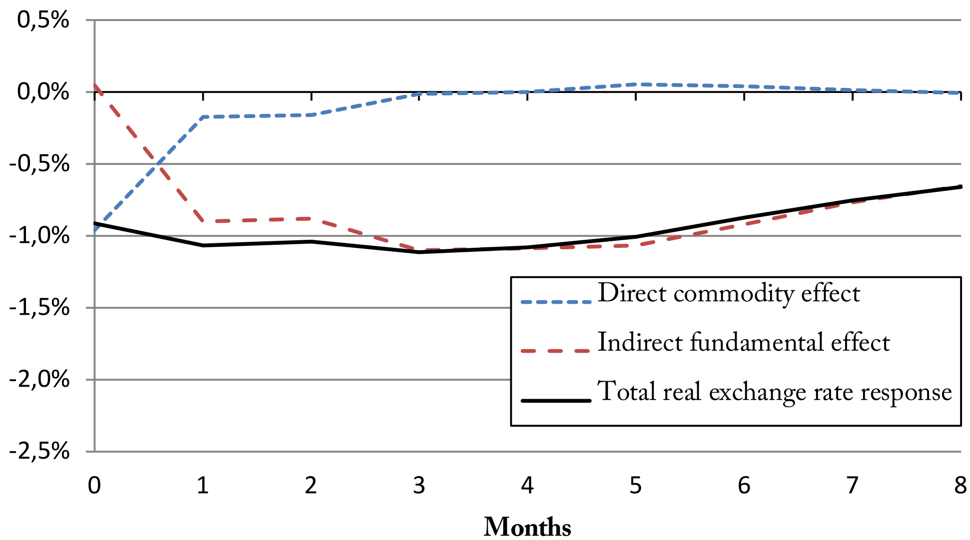
4.5.2.5. Direct and indirect effect of a commodity prices shock on real exchange rates

Figure 12. Direct commodity prices effect, indirect fundamental effect and total real exchange rate response to a commodity prices shock, Canada, 1972 M1 – 1998 M12 subsample



Notes. See **Figure 5.a.**

Figure 13. Direct commodity prices effect, indirect fundamental effect and total real exchange rate response to a commodity prices shock, Canada, 1999 M1 – 2012 M10 subsample

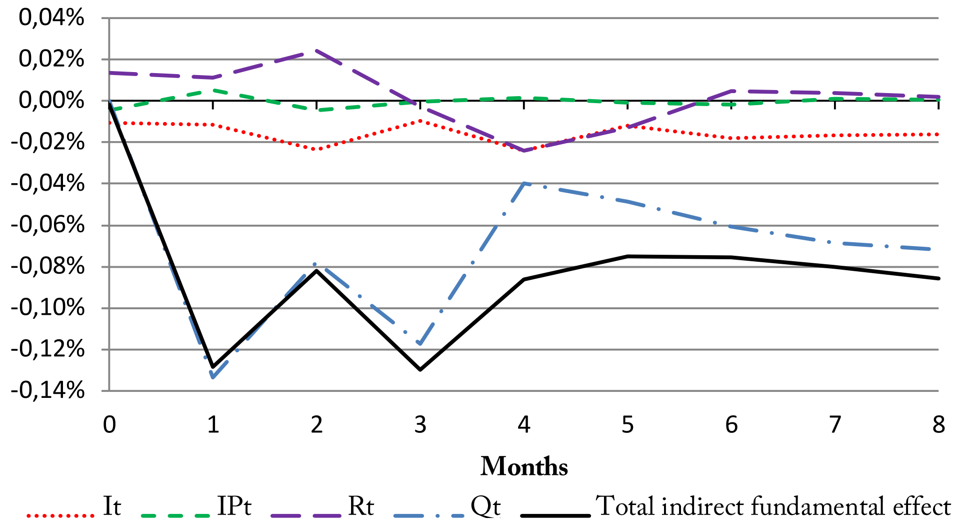


Notes. See **Figure 5.a.**

In the first subsample, the direct and indirect effects appear somewhat unstable, though our main conclusions remain valid for both periods. As it is the case with quarterly data, the direct effect dominates at impact, as the indirect one is close to zero. One month after the shock, the indirect effect takes the upper hand, while the direct effect starts to die out four periods after the shock and onwards. These results suggest that our findings are relatively robust in their movements but not as much in their duration: using a quarterly frequency, the direct and indirect effects also start to die out after four periods, except that these periods were quarters, not months.

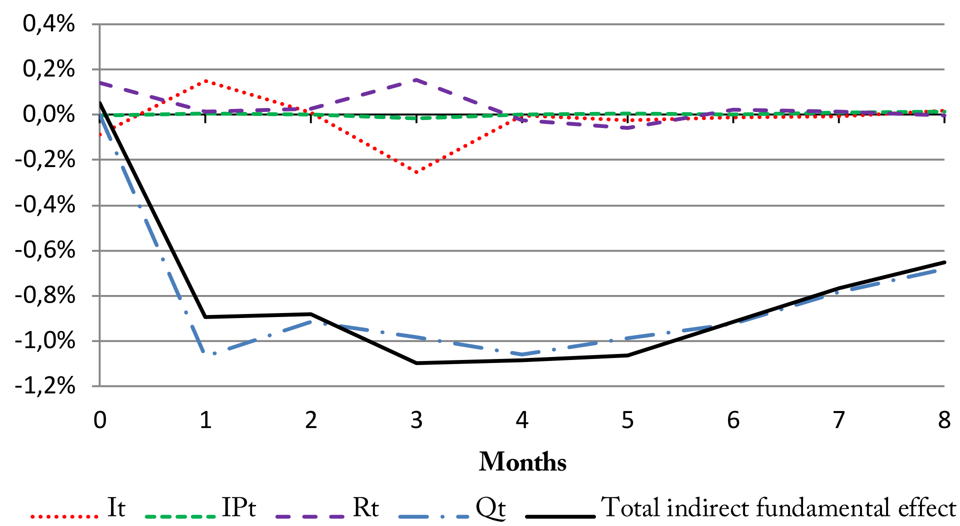
4.5.2.6. Decomposition of the indirect effect of a commodity prices shock on real exchange rates

Figure 14. Consumer Price Index (It), Industrial Production (IPt), Real Interest Rates (Rt) and Real Exchange Rates (Qt) components of the indirect effect of a commodity prices shock, Canada, 1972 M1 – 1998 M12 subsample



Notes. See **Figure 5.b.**

Figure 15. Consumer Price Index (It), Industrial Production (IPt), Real Interest Rates (Rt) and Real Exchange Rates (Qt) components of the indirect effect of a commodity prices shock, Canada, 1999 M1 – 2012 M10 subsample



Notes. See **Figure 5.b.**

Apart from the differences in the whole indirect effect itself, these graphs are similar to the one obtained from quarterly Canadian data. The indirect effect is at any time after the shock driven by past exchange rate responses (the Qt component on the above graph). The influence of individual fundamentals appears more important with monthly data, but their effects seem to cancel each other out. For instance, the increase in CPI resulting from a positive commodity prices shock usually appreciates the real exchange rate (i.e. the It line usually is below zero), whereas the decrease in real interest rates also triggered by the shock tends to depreciate the real exchange rate (the Rt line is usually above zero).

4.5.3. Robustness test including the trade balance instead of real economic activity

As the use of two subsamples in the previous robustness tests did not materially affect our results, this second test will be performed considering the overall sample, ranging from 1972 to 2012. Two important changes are made in the following robustness analysis. Real economic activity (i.e. real GDP or industrial production) is replaced by the trade balance in value, in order to account for variations in the commodity export prices. Additionally, the real exchange rate measure was changed from monthly averages to month-end values, which result in more volatile exchange rate series.

4.5.3.1. Unit root tests

As the level of the trade balance is sometimes negative and highly volatile, it is not logged and its unit root test is performed without including a time trend. The test details are available in appendix B.2.

All variables contain unit roots; they are consequently included in the SVECM as their first differences.

4.5.3.2. Cointegration tests

Unlike samples including real GDP or industrial production, the Canadian data with trade balance seems to contain two cointegration relations. The Johansen test details for this sample are available in appendix D.2.

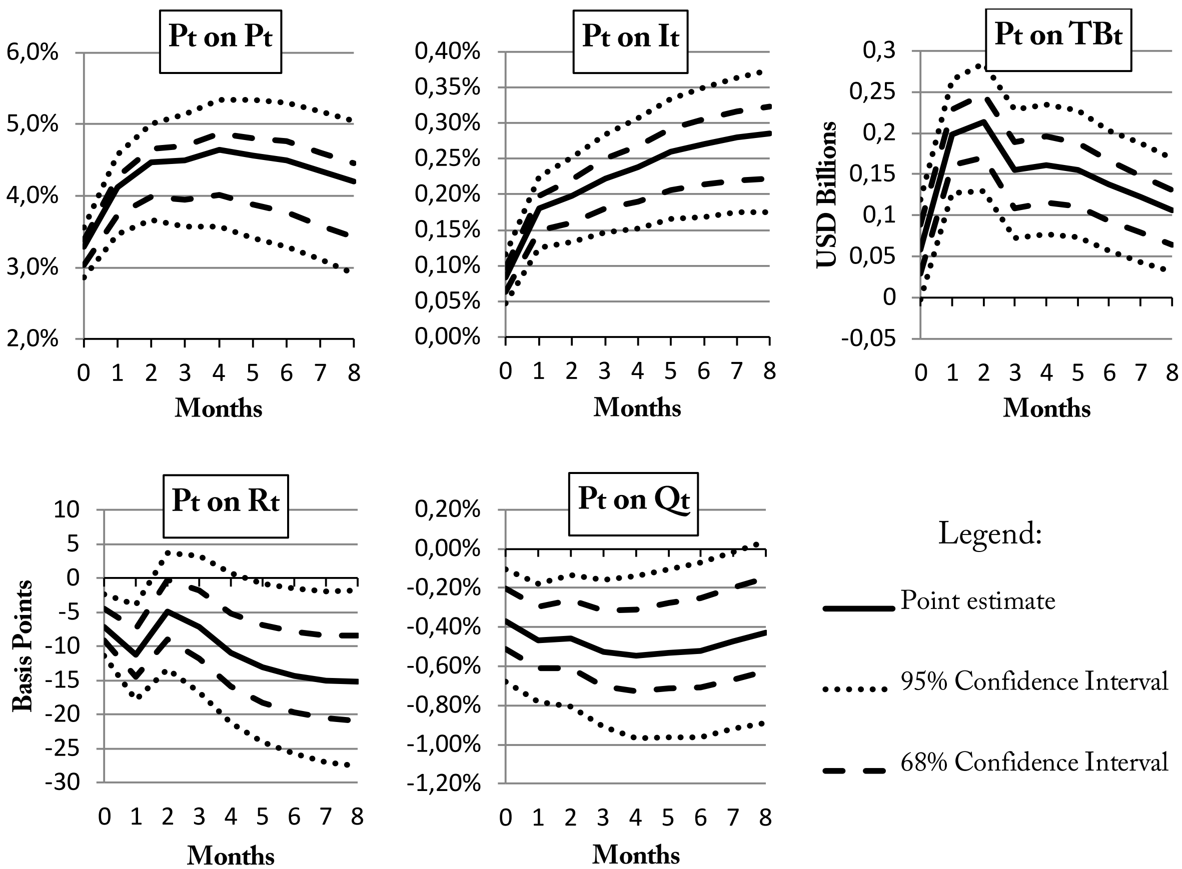
4.5.3.3. Overview of the results when including trade balance instead of real economic activity

The abbreviations included in the following graphs are identical to the ones used earlier, with the exception of Trade Balance (TBt) that replaces the real GDP (Yt) and Industrial Production (IPt).

The inclusion of the trade balance, instead of a real economic activity measure, and the use of month-end exchange rates result in a more sustainable influence of domestic commodity prices on the Canadian real exchange rate. Also, the direct speculative effect appears more sustainable using this sample, as it is significant up to two months after the initial commodity prices shock.

4.5.3.4. Impulse responses to a domestic commodity prices shock

Figure 16. Commodity prices effect on Canadian fundamentals and real exchange rate, 1972 M1 – 2012 M10 sample with trade balance

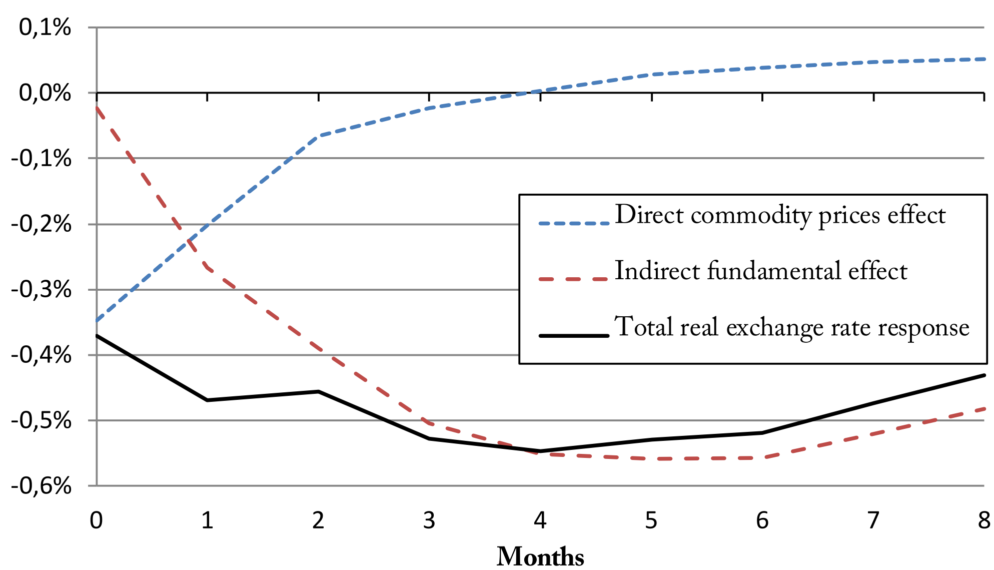


Notes. See **Figure 4.** Like the real interest rates, the monthly Trade Balance is not logged, so response of the variable to a unit standard deviation shock in commodity prices is presented in absolute terms, in billions of US dollars (USD).

As showed by the "Pt on Qt" graph in **Figure 16**, the effect of a commodity prices shock on the real exchange rate lasts for seven months at the 95% confidence level, in line with our findings using quarterly data that resulted in a significant duration of two quarters. Similarly consistent with quarterly data, the positive effect on CPI is permanent, even at the 99% level (99% confidence level intervals are not presented graphically). A surprise increase in commodity prices also significantly improves the Canadian balance of trade, and the effect is sustainable as it lasts for almost a year (ten months at the 95% level). Compared to the GDP, in Canada commodities are more important for exports, the effect of commodity prices on the trade balance is thus intuitively much stronger than on the overall GDP. Finally, real interest rates are instantaneously decreased by a commodity prices shock, but this time the effect is permanent from five months after the shock and onwards. This was not the case with our previous samples and may be explained by a stronger positive effect on CPI, which decreases interest rates once adjusted for inflation.

4.5.3.5. Direct and indirect effect of a commodity prices shock on real exchange rates

Figure 17. Direct commodity prices effect, indirect fundamental effect and total real exchange rate response to a commodity prices shock, Canada, 1972 M1 – 2012 M10 sample with trade balance



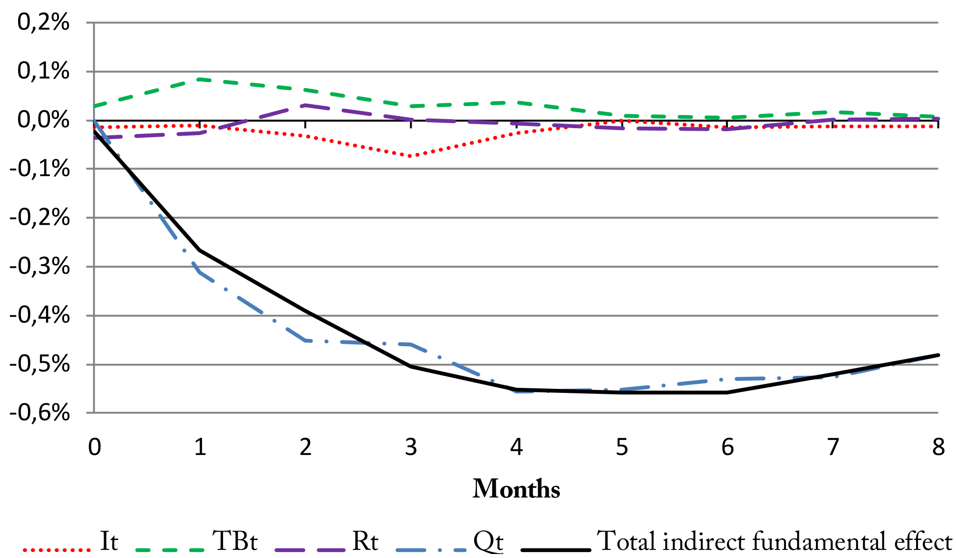
Notes. See **Figure 5.a.**

Although the total exchange rate response is more sustainable when including the balance of trade in the SVECM, the direct and indirect effects exhibit similar patterns in all samples.

At impact, the total response is almost entirely driven by the direct, speculative effect, as fundamentals can be sticky in the short run. The main difference between this sample and the two previous subsamples is that the direct effect is substantial for two months, instead of one. From three months after the shock and onwards, the total real exchange rate response is dominated by the indirect, fundamental effect. The speculative component is then negligible.

4.5.3.6. Decomposition of the indirect effect of a commodity prices shock on real exchange rates

Figure 18. Consumer Price Index (It), Trade Balance (TBt), Real Interest Rates (Rt) and Real Exchange Rates (Qt) components of the indirect effect of a commodity prices shock, Canada, 1972 M1 – 2012 M10 sample with trade balance



Notes. See **Figure 5.b.**

The strong impact of commodity prices on the trade balance appears to have a non-significant influence on the exchange rate response to a commodity prices shock, in contradiction with the most cited rationale in the commodity currency literature, the export channel (see section 4.2.1.). The trade balance contribution to the indirect, fundamental effect (see the TBt line in the above graph) does not appear more significant than that of real interest rates (Rt line) or

CP (It line). Therefore, as it is the case for Australia and Canada -considering any sample, the indirect effect is dominated by past real exchange rate responses to the initial commodity prices shock.

4.6. Conclusion

This article investigates whether fundamental macroeconomic variables explain the link between commodity prices and commodity currencies, or if this link appears to be mostly the consequence of speculation and expectations about future exchange rates. Three commodity currencies are studied, the Australian, Canadian, and New Zealand dollars, with quarterly data over different periods as they were floated at different times.

The influence of speculative demand and macroeconomic fundamentals on commodity currencies is analyzed using a SVECM. This type of model takes into account cointegration relations that are often present in long-run macroeconomic data. It also allows for contemporaneous interactions of the five variables we consider: domestic commodity prices, CPI, real GDP, real interest rates, and real exchange rates. More specifically, the respective influences of speculation and fundamentals are disentangled by decomposing the response of the real exchange rate to a domestic commodity prices shock. We show that this response depends on the commodity prices effect on each of the five variables included in the model. The part of the real exchange rate response that is only a function of commodity prices represents the speculative effect of the shock, as it is not explained by fundamental variables. The part that depends on variables other than commodity prices (i.e. CPI, real GDP, real interest rates, and past real exchange rates) represents the fundamental effect of the shock.

The key finding of this article consequently resides in the breakdown of the real exchange rate response to a domestic commodity prices shock. This decomposition provides results that are consistent with the economics of exchange rates and similar across the three selected countries. At the time of the shock, the resulting significant real exchange rate appreciation is almost entirely driven by the speculative effect, which seems to account for expectations about future exchange rates. This effect becomes negligible after one quarter in Australia and Canada, although it appears sustainable in New Zealand. The influence of speculative demand on the

New Zealand dollar is also confirmed by its higher sensitivity to world commodity prices than domestic commodity prices. Finally, from one quarter after the shock and onwards, in all three countries the real appreciation is dominated by the fundamental effect. As the speculative effect has a much less sustainable lifespan than its fundamental counterpart, the link between commodity prices and commodity currencies appears mostly explained by the commodity prices effect on the macroeconomic fundamentals of the considered economies.

Additionally, this article presents two other types of findings. First, in Australia and Canada, the fundamental effect is dominated at any time after the shock by the strong persistence of real exchange rate movements in response to a domestic commodity prices shock. In New Zealand, the fundamental effect mainly depends on two components, the persistence of real exchange rate movements, and the effect of commodity prices on the CPI. Consequently, the CPI can be considered as a valid transmission channel between commodity prices and the real exchange rate in this country.

Second, this paper confirms the findings of the literature by demonstrating the significant impact of commodity prices on both the real exchange rates and the macroeconomic fundamentals of the selected countries. A commodity prices shock influences the real exchange rates, CPI, and real interest rates in all three countries at the 95% level of confidence. However, the effect on real GDP is only significant in Canada.

This analysis could be extended in further research. Only positive shocks in commodity prices are considered in this paper, while an examination of both positive and negative shocks that may have asymmetric effects on exchange rates and fundamentals could prove insightful. Finally, as exchange rates and commodity prices are financial series, taking into account clustered volatility by incorporating elements of Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) models would lead to more precise estimates.

4.7. References

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4.8. Appendices

A. Data sources

1. Australia

Variable	Source
Commodity prices	Reserve Bank of Australia (RBA) Index of commodity prices, US dollar terms. Australian bureau of Statistics. Series' mnemonic: GRCPAIUSD.
Consumer price index	International Monetary Fund (IMF), International Financial Statistics (IFS), consumer prices, all items.
Real interest rates	Reserve Bank of Australia (RBA), Australian government bond yield, 5-year maturity. Adjusted for the domestic CPI. Series' mnemonic: FCMYGBAG5.
Real GDP	IMF, IFS, real GDP (expenditure approach).
Real exchange rate	IMF, IFS, nominal exchange rate vis-à-vis the US dollar, quarterly average, adjusted for the relative Australian/US CPI.

2. Canada

2.1 Quarterly frequency

Variable	Source
Commodity prices	Bank of Canada index of commodity prices (BCPI) in US dollar terms, quarterly frequency. CANSIM table # 176-0075.
Consumer price index	IMF, IFS, consumer prices, all items.
Real interest rates	IMF, IFS, interest rates, government securities, government bonds, short-term (average 3 to 5-year rate). Adjusted for the domestic CPI.
Real GDP	IMF, IFS, real GDP (expenditure approach).
Real exchange rate	IMF, IFS, nominal exchange rate vis-à-vis the US dollar, quarterly average, adjusted for the relative Canadian/US CPI.

2.2 Monthly Frequency

Variable	Source
Commodity prices	Bank of Canada index of commodity prices (BCPI) in US dollar terms, monthly frequency. CANSIM table # 176-0075.
Consumer price index	IMF, IFS, consumer prices, all items.
Real interest rates	IMF, IFS, interest rates, government securities, government bonds, short-term (average 3 to 5-year rate). Adjusted for the domestic CPI.
Industrial production	IMF, IFS, index of industrial production (monthly real GDP proxy).
Trade balance	IMF, IFS, external trade, value of good exports minus value of good imports, in US dollar terms.
Real exchange rate	IMF, IFS, nominal exchange rate vis-à-vis the US dollar, adjusted for the relative Canadian/US CPI. Monthly averages (section 4.5.2.) and month-end values (section 4.5.3.)

3. New Zealand

Variable	Source
Domestic commodity prices	ANZ Bank commodity prices index, US dollar terms. Construction methodology and data available at: http://www.anz.co.nz/commercial-institutional/economic-markets-research/commodity-price-index/
World commodity prices	IMF primary commodity prices index, monthly data in US dollar terms averaged quarterly. Series available at: http://www.imf.org/external/np/res/commod/index.aspx
Consumer price index	IMF, IFS, consumer prices, all items.
Real interest rates	Reserve Bank of New Zealand, secondary market government bond yield, 5-year maturity. Adjusted for the domestic CPI.
Real GDP	IMF, IFS, real GDP (expenditure approach).
Real exchange rate	IMF, IFS, nominal exchange rate vis-à-vis the US dollar, quarterly average, adjusted for the relative New Zealand/US CPI.

B.1. Unit root tests with quarterly data

Variable	Type of ADF test	Australia: Adjusted P-value of ADF test	Australia: Number of lags (k) included in the regression	Canada: Adjusted P-value of ADF test	Canada: Number of lags (k) included in the regression	New-Zealand: Adjusted P-value of ADF test	New-Zealand: Number of lags (k) included in the regression	Test conclusion for all countries
Log Commodity Prices Index	Random walk with drift	0.9586	2	0.4638	4	0.9962	8	Fails to reject the null hypothesis of a unit root.
Log Consumer Price Index	Random walk with drift and trend	0.5878	2	0.0844	4	0.3117	3	
Real Interest Rates	Random walk with drift	0.3771	9	0.4598	4	0.8305	8	
Log Real GDP	Random walk with drift and trend	0.3839	5	0.5018	4	0.1898	0	
Log Real Exchange Rates	Random walk with drift	0.4833	1	0.4904	4	0.2880	1	

Notes. This test evaluates the presence of unit roots by estimating an AR(p) model for a selected variable Y_t : $\Delta Y_t = \delta + \alpha t + \gamma Y_{t-1} + \sum_{i=2}^{k} \beta_i \Delta Y_{t-i+1} + \varepsilon_t$, where Δ is the first difference operator. δ and αt are optional, respectively representing a drift and a deterministic trend. The null hypothesis of the presence of a unit root is $\gamma = 0$. The conclusions of the test, stating whether we reject or not the presence of a unit root in a given variable, are presented based on a 95% confidence level.

B.2. Unit root tests with monthly data

		Canada, 1972 M1 – 1998 M12 subsample		Canada, 1999 M1 – 2012 M10 subsample		Canada, 1972 M1 – 2012 M10 sample with trade balance		
Variable	Type of ADF test	Adjusted P-value of ADF test	Number of lags (k) included in the regression	Adjusted P-value of ADF test	Number of lags (k) included in the regression	Adjusted P-value of ADF test	Number of lags (k) included in the regression	Test conclusion
Log Commodity Prices Index	Random walk with drift	0.0047	8	0.4893	5	0.3493	5	Fails to reject the null hypothesis of a unit root except for commodity prices in the 1972 M1 – 1998 M12 subsample
Log Consumer Price Index	Random walk with drift and trend	0.9960	4	0.4079	8	0.0909	8	
Real Interest Rates	Random walk with drift	0.1933	1	0.0945	0	0.0833	1	
Log Real GDP	Random walk with drift and trend	0.0649	7	0.3003	3	0.2547	10	
Log Real Exchange Rates	Random walk with drift	0.7740	10	0.7530	1	0.5173	1	

Notes. See appendix B.1.

C. Lag structure determination of the underlying VAR models.

In the following tables, an asterisk (*) denotes the optimal number of lag according to the considered criterion. The upper lag number limit is set to seven. The bold number in the "Lag number" column indicates the chosen number of lags for the underlying VAR form of the SVECM.

1. Australia

Australia. Overall sample: 1982 Q3 – 2012 Q4

Lag number	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	721.439				2.4e-12	-12.5691	-12.5204	-12.4491
1	785.327	127.78	25	0.000	1.2e-12	-13.2514	-12.9591	-12.5313*
2	824.369	78.084	25	0.000	9.5e-13*	-13.4977*	-12.9619*	-12.1776
3	842.145	35.553	25	0.079	1.1e-12	-13.371	-12.5917	-11.4508
4	863.361	42.432*	25	0.016	1.2e-12	-13.3046	-12.2818	-10.7844
5	876.675	26.628	25	0.375	1.5e-12	-13.0996	-11.8332	-9.97934
6	887.012	20.674	25	0.711	2.0e-12	-12.8423	-11.3325	-9.12205
7	901.052	28.079	25	0.304	2.5e-12	-12.65	-10.8967	-8.32971

Notes. The following criteria are presented, after estimating VAR models using one to seven lags for all variables included in the model. LL represents the log likelihood of the estimated VAR model. LR represents the Likelihood Ratio test of significance of the variables included in the model with the highest lag order, with its associated degrees of freedom (df) and p-value (p). Akaike's Final Prediction Error (FPE) simulates in-sample forecasting, so that the best lag choice produces the smallest prediction error. Finally, three information criteria are utilized: Akaike's Information Criteria (AIC), the Hannan-Quinn Information Criterion (HQIC) and the Schwartz Bayesian Information Criteria (SBIC). They all assess the best model fit using the corresponding log likelihood result and the number of observations in each sample.

2. Canada

2.1. Quarterly frequency

Canada. Overall sample: 1972 Q1 – 2012 Q4

Lag number	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1201.89				1.5e-13	-15.3448	-15.3051	-15.247
1	1330.75	257.71	25	0.000	3.9e-14*	-16.6763*	-16.4381*	-16.0898*
2	1351.64	41.789	25	0.019	4.2e-14	-16.6236	-16.1869	-15.5484
3	1373.84	44.392	25	0.010	4.3e-14	-16.5877	-15.9524	-15.0237
4	1399.82	51.971*	25	0.001	4.3e-14	-16.6003	-15.7666	-14.5475
5	1410.46	21.265	25	0.678	5.2e-14	-16.4161	-15.3839	-13.8746
6	1423.81	26.701	25	0.371	6.1e-14	-16.2668	-15.036	-13.2365
7	1436.99	26.364	25	0.388	7.2e-14	-16.1153	-14.686	-12.5962

Notes. See appendix C.1.

2.2. Monthly frequency

Canada. 1972 M1 – 1998 M12 subsample

Lag number	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	3542.22				1.3e-16	-22.3875	-22.3638	-22.3281
1	3624.88	165.3	25	0.000	9.0e-17	-22.7524	-22.6099*	-22.3958*
2	3654.55	59.354	25	0.000	8.8e-17*	-22.782*	-22.5208	-22.1283
3	3677.87	46.635	25	0.005	8.9e-17	-22.7713	-22.3915	-21.8205
4	3701.42	47.092	25	0.005	9.0e-17	-22.7621	-22.2636	-21.5142
5	3721.68	40.535*	25	0.026	9.2e-17	-22.7322	-22.1149	-21.1871
6	3731.94	20.52	25	0.719	1.0e-16	-22.6389	-21.9029	-20.7967
7	3747.04	30.184	25	0.217	1.1e-16	-22.5762	-21.7215	-20.4368

Notes. See appendix C.1.

Canada. 1999 M1 – 2012 M10 subsample

Lag number	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1633.8				2.1e-15	-19.6241	-19.5861*	-19.5304*
1	1667.51	67.414	25	0.000	1.9e-15*	-19.729*	-19.5008	-19.1666
2	1685.66	36.306	25	0.067	2.0e-15	-19.6465	-19.228	-18.6155
3	1700.21	29.1	25	0.260	2.3e-15	-19.5206	-18.9119	-18.0209
4	1714.63	28.837	25	0.271	2.6e-15	-19.3932	-18.5942	-17.4247
5	1738.76	48.26*	25	0.003	2.7e-15	-19.3827	-18.3934	-16.9456
6	1752.85	28.185	25	0.299	3.1e-15	-19.2513	-18.0718	-16.3455
7	1770.46	35.207	25	0.085	3.4e-15	-19.1621	-17.7924	-15.7877

Notes. See appendix C.1.

Canada. 1972 M1 – 2012 M10 sample with trade balance

Lag number	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1369.09				2.4e-09	-5.66013	-5.6431	-5.61679
1	1460.58	182.97	25	0.000	1.8e-09	-5.936	-5.8338*	-5.67596*
2	1491.7	62.248	25	0.000	1.8e-09*	-5.96141*	-5.77405	-5.48467
3	1506.3	29.195	25	0.256	1.9e-09	-5.91824	-5.64572	-5.22481
4	1532.54	52.48	25	0.001	1.8e-09	-5.92339	-5.5657	-5.01326
5	1554.43	43.779	25	0.011	1.9e-09	-5.91048	-5.46763	-4.78365
6	1575.15	41.451	25	0.021	1.9e-09	-5.89274	-5.36472	-4.54921
7	1597.89	45.48*	25	0.007	1.9e-09	-5.88337	-5.27018	-4.32314

Notes. See appendix C.1.

3. New Zealand

New Zealand. Overall sample: 1986 Q1 – 2012 Q3

Lag number	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	560.502				9.2e-12	-11.2223	-11.1692	-11.0912*
1	599.002	77.001	25	0.000	7.0e-12*	-11.495	-11.1768*	-10.7086
2	616.609	35.214	25	0.084	8.2e-12	-11.3456	-10.7623	-9.9039
3	632.524	31.831	25	0.163	9.9e-12	-11.1621	-10.3136	-9.06504
4	662.822	60.595	25	0.000	9.1e-12	-11.2691	-10.1555	-8.51673
5	681.677	37.71	25	0.049	1.1e-11	-11.145	-9.76621	-7.73725
6	708.956	54.559	25	0.001	1.1e-11	-11.191	-9.54711	-7.12797
7	749.249	80.587*	25	0.000	8.3e-12	-11.5*	-9.59092	-6.78159

Notes. See appendix C.1.

Four lags are chosen for Australia and Canada using a quarterly data frequency. For the two Canadian monthly subsamples, five lags seem more appropriate.

As for the Canadian monthly sample including trade balance and New Zealand, the LR criterion consistently indicates the maximum number of lag allowed (up to 15 lags), while most other criteria remain stable in their one or two lags indication. As a compromise, a lag number of five was chosen for both samples.

D.1. Johansen cointegration tests with quarterly data

	Australia. Selected number of lags: 4.			Canada. Selected number of lags: 4.			New-Zealand. Selected number of lags: 5.		
Maximum rank	Eigenvalue	Trace Statistic	5% critical value	Eigenvalue	Trace Statistic	5% critical value	Eigenvalue	Trace Statistic	5% critical value
0	.	110.9466	68.52	.	81.8491	68.52	.	106.7636	68.52
1	0.4591	**38.4264**	47.21	0.2272	**40.6208**	47.21	0.4186	51.4552	47.21
2	0.1325	21.6604	29.68	0.1069	22.5252	29.68	0.2656	**19.9748**	29.68
3	0.0998	9.2497	15.41	0.0679	11.2819	15.41	0.1360	5.0655	15.41
4	0.0638	1.4703	3.76	0.0361	5.3926	3.76	0.0477	0.0828	3.76
5	0.0124			0.0331			0.0008		

Notes. To apply the Johansen test, the following VEC(p) is first estimated: $\Delta X_t = \delta + \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t$, where Δ is the first difference operator. If X_t is a $(N \times 1)$ vector containing N variables in levels ($N = 5$ in our case) then Π is a $(N \times N)$ matrix defined as $\Pi = \alpha\beta'$. α is a $(N \times r)$ matrix containing parameters representing the speed at which the variables revert to their long-run equilibrium and β' is a $(r \times N)$ matrix including r cointegration relations between the variables contained in X_t. The Trace test is used, but similar results are obtained when the eigenvalue test is applied. The null hypothesis of the trace test is H_0: $r \leq x$ and the alternative H_1: $r > x$, where r is the rank of Π and $x < N$. Under the eigenvalue test, only the alternative hypothesis differs: the null is still H_0: $r \leq x$ while the alternative becomes H_1: $r = x + 1$. The number of lags in the VEC model is determined from the lag structure of the underlying VAR model. The criteria and results for the lag structures can be found in appendix C. In this table, the most significant Johansen test trace statistic is indicated in bold type. The number of cointegration relations corresponds to the rank that is used to compute this most significant test statistic.

D.2. Johansen cointegration tests with monthly data

	Canada, 1972 M1 – 1998 M12 subsample. Selected number of lags: 5.			Canada, 1999 M1 – 2012 M10 subsample. Selected number of lags: 5.			Canada, 1972 M1 – 2012 M10 sample with trade balance. Selected number of lags: 5.		
Maximum rank	Eigenvalue	Trace Statistic	5% critical value	Eigenvalue	Trace Statistic	5% critical value	Eigenvalue	Trace Statistic	5% critical value
0	.	77.8586	68.52	.	93.1246	68.52	.	105.3439	68.52
1	0.0981	**44.9278**	47.21	0.2756	**39.6118**	47.21	0.10673	50.6023	47.21
2	0.0748	20.1193	29.68	0.0946	23.1103	29.68	0.05498	**23.1757**	29.68
3	0.0362	8.3682	15.41	0.0780	9.6239	15.41	0.03262	7.0929	15.41
4	0.0258	0.0207	3.76	0.0516	0.8390	3.76	0.01208	1.2002	3.76
5	0.0001			0.0050			0.00247		

Notes. See appendix D.1.

E. Estimates of the SVECM parameters for each country.

The following model is estimated and identified by maximum likelihood using the scoring algorithm mentioned in section 4.3.2. for each country:

$$\Delta X_t = C + \pi X_{t-1} + \mathrm{A}_1 \Delta X_{t-1} + \mathrm{A}_2 \Delta X_{t-2} + \ldots + \mathrm{A}_p \Delta X_{t-p} + BU_t \ , \qquad (12)$$

$$\text{with } \pi = \alpha\beta'.$$

The estimates from equation *(12)* can then be easily converted to the initial structural model described by *(1)*, by multiplying each term by B^{-1}:

$$B^{-1}\Delta X_t = B^{-1}C + B^{-1}\pi X_{t-1} + B^{-1}\mathrm{A}_1 \Delta X_{t-1} + B^{-1}\mathrm{A}_2 \Delta X_{t-2} + \ldots + B^{-1}\mathrm{A}_p \Delta X_{t-p} + U_t,$$

$$\Theta \Delta X_t = \delta + \Pi X_{t-1} + \Phi_1 \Delta X_{t-1} + \Phi_2 \Delta X_{t-2} + \ldots + \Phi_p \Delta X_{t-p} + U_t,$$

which is the SVECM equation described in *(1),* with $\Theta = B^{-1}$.

The following tables present estimates of the model described by *(12)*, with their associated standard errors in parentheses. The standard errors of the coefficients included in the structural matrix (*B*) are bootstrapped using the method that was described in section 4.3.4. for confidence intervals.

***, **, and * respectively indicate coefficients that are significant at the 99%, 95% and 90% levels of confidence.

1. Structural matrices B (contemporaneous influences between variables)

Matrix Element	Australia	Canada, quarterly data	Canada, monthly data, 1st subsample	Canada, monthly data, 2nd subsample	Canada, monthly data, with trade balance	New Zealand
$B_{1,1}$	0.0364***	0.0574***	0.0193***	0.0462***	0.0329***	0.0326***
	(0.0047)	(0.0075)	(0.0011)	(0.0036)	(0.0020)	(0.0050)
$B_{2,1}$	0.0020***	0.0023***	0.0002	0.0014***	0.0008***	0.0008*
	(0.0006)	(0.0006)	(0.0001)	(0.0003)	(0.0002)	(0.0005)
$B_{2,2}$	0.0061***	0.0044***	0.0031***	0.0028***	0.0031***	0.0042***
	(0.0009)	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0007)
$B_{3,1}$	0.0005	0.0016***	0.0009	0.0004	0.0589*	0.0009
	(0.0007)	(0.0005)	(0.0007)	(0.0002)	(0.0312)	(0.0010)
$B_{3,2}$	0.0000	-0.0011**	-0.0016**	-0.0002	-0.1152***	0.0009
	(0.0007)	(0.0005)	(0.0007)	(0.0002)	(0.0284)	(0.0012)
$B_{3,3}$	0.0060***	0.0056***	0.0119***	0.0028***	0.6070***	0.0095***
	(0.0007)	(0.0005)	(0.0009)	(0.0003)	(0.0377)	(0.0014)
$B_{4,1}$	-0.0001	-0.0009	0.0003	-0.0016***	-0.0007***	0.0003
	(0.0006)	(0.0006)	(0.0003)	(0.0004)	(0.0002)	(0.0005)
$B_{4,2}$	-0.0038***	-0.0020***	-0.0023***	-0.0020***	-0.0020***	-0.0037***
	(0.0007)	(0.0006)	(0.0004)	(0.0004)	(0.0003)	(0.0007)
$B_{4,3}$	0.0000	-0.0009	0.0004	-0.0006**	-0.0003*	0.0002
	(0.0005)	(0.0006)	(0.0003)	(0.0003)	(0.0002)	(0.0004)
$B_{4,4}$	0.0061***	0.0067***	0.0056***	0.0038***	0.0053***	0.0039***
	(0.0007)	(0.0006)	(0.0004)	(0.0004)	(0.0003)	(0.0006)
$B_{5,1}$	-0.0229***	-0.0088***	-0.0011**	-0.0091***	-0.0037**	-0.0104*
	(0.0069)	(0.0031)	(0.0005)	(0.0019)	(0.0015)	(0.0053)
$B_{5,2}$	-0.0028	0.0009	-0.0030***	0.0001	-0.0021**	-0.0082
	(0.0041)	(0.0019)	(0.0006)	(0.0013)	(0.0009)	(0.0044)
$B_{5,3}$	-0.0032	-0.0010	-0.0004	0.0003	0.0027***	-0.0046
	(0.0041)	(0.0016)	(0.0005)	(0.0011)	(0.0010)	(0.0036)
$B_{5,4}$	-0.0030	0.0026*	0.0024***	-0.0034**	0.0027***	-0.0038
	(0.0037)	(0.0016)	(0.0006)	(0.0014)	(0.0008)	(0.0034)
$B_{5,5}$	0.0403***	0.0198***	0.0095***	0.0154***	0.0173***	0.0374***
	(0.0050)	(0.0020)	(0.0005)	(0.0016)	(0.0010)	(0.0061)

Notes. This table presents estimates of the matrix B described in *(12)*. This matrix is lower triangular, as explained in the subsection dedicated to the identification of the SVECM (4.4.1.3.).

2. Cointegration relations

As New Zealand and the Canadian data with trade balance are the only samples that exhibit more than one cointegration relation, their cointegration estimates are presented separately in table 2.3.

2.1. Matrices alpha (speed of adjustment parameters) for Australia and Canada without trade balance

Matrix Element	Australia	Canada, quarterly data	Canada, monthly data, 1st subsample	Canada, monthly data, 2nd subsample
$\alpha_{1,1}$	-0.0050*	-0.0198	0.0055	-0.2584***
	(0.0030)	(0.0125)	(0.0077)	(0.0470)
$\alpha_{2,1}$	-0.0016***	-0.0030***	0.0089***	-0.0011
	(0.0005)	(0.0011)	(0.0012)	(0.0032)
$\alpha_{3,1}$	0.0012**	0.0049***	0.0033	-0.0084***
	(0.0005)	(0.0013)	(0.0048)	(0.0029)
$\alpha_{4,1}$	0.0053***	0.0105***	0.0026	-0.0013
	(0.0006)	(0.0016)	(0.0024)	(0.0047)
$\alpha_{5,1}$	-0.0037	0.0114**	-0.0018	0.0203
	(0.0038)	(0.0048)	(0.0041)	(0.0185)

Notes. This table presents estimates of the vector α described in *(12)*. This vector contains parameters that represent the speed at which cointegrated variables adjust back to their long term equilibrium.

2.2. Matrices beta (cointegration relations) for Australia and Canada without the trade balance

Matrix Element	Australia	Canada, quarterly data	Canada, monthly data, 1st subsample	Canada, monthly data, 2nd subsample
$\beta_{1,1}$	1	1	1	1
	-	-	-	-
$\beta_{2,1}$	0.4164	4.3103***	-0.8957***	2.0705**
	(2.2312)	(0.6590)	(0.1184)	(0.8502)
$\beta_{3,1}$	-11.3420**	-8.5416***	0.2171	-2.1852***
	(2.2660)	(0.9565)	(0.2650)	(0.8211)
$\beta_{4,1}$	-121.8670**	-33.5573***	-1.2823	-0.1344
	(12.8062)	(4.2880)	(1.0695)	(1.4723)
$\beta_{5,1}$	-1.9461**	1.4242***	-0.2596	2.0261***
	(0.8676)	(0.4391)	(0.2460)	(0.2360)

Notes. This table presents estimates of the vector β described in *(12)*. This vector contains estimates of the linear cointegration relation between cointegrated variables.

2.3. Estimates of the matrices alpha and beta for New Zealand and the Canadian monthly sample with trade balance

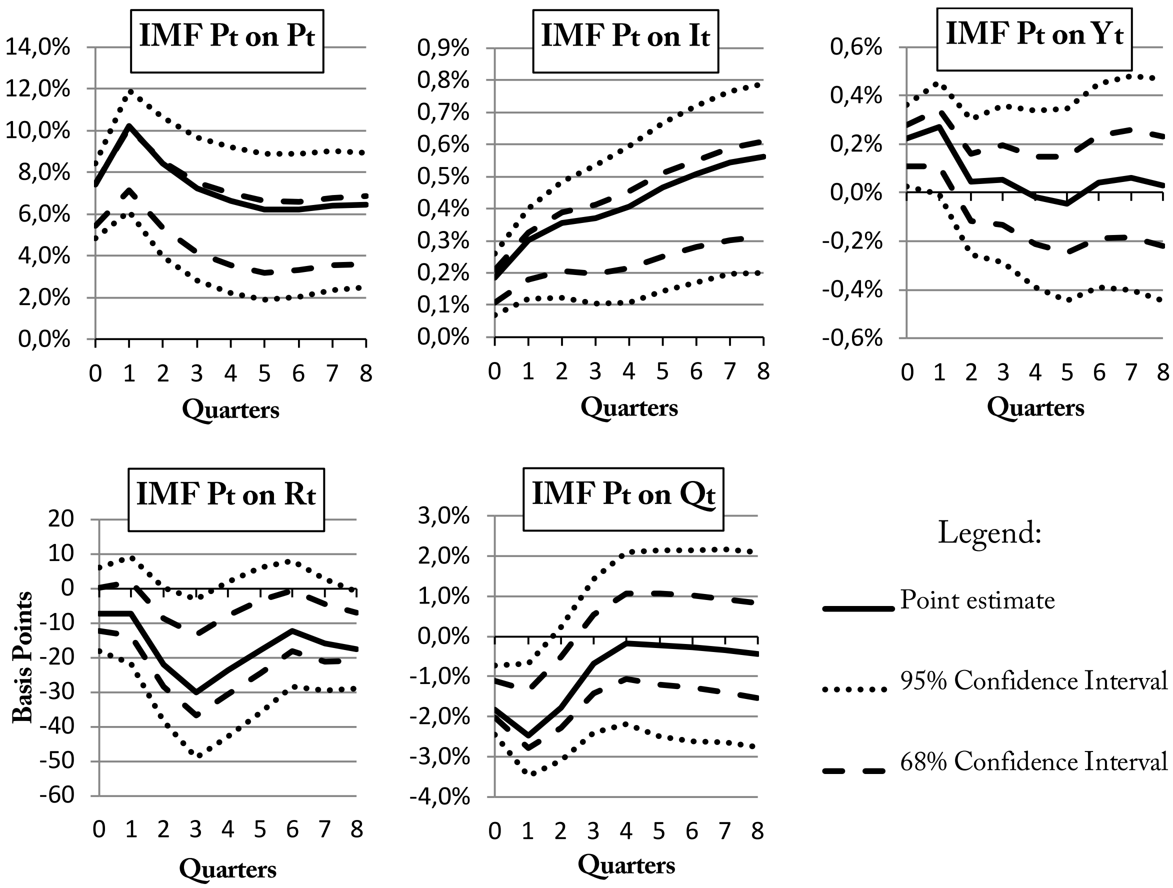
Alpha Matrix Element	New Zealand	Canada, monthly data, with trade balance	Beta Matrix Element	New Zealand	Canada, monthly data, with trade balance
$\alpha_{1,1}$	-0.1423***	0.0070	$\beta_{1,1}$	1	1
	(0.0452)	(0.0052)		-	-
$\alpha_{2,1}$	0.0214***	0.0033***	$\beta_{2,1}$	0	0
	(0.0060)	(0.0005)		-	-
$\alpha_{3,1}$	-0.0237*	-0.0052	$\beta_{3,1}$	0.3738*	7.4157***
	(0.0133)	(0.0978)		(0.1653)	(1.3971)
$\alpha_{4,1}$	-0.0135*	-0.0004	$\beta_{4,1}$	15.8433***	93.0824
	(0.0075)	(0.0009)		(1.9815)	(58.4325)
$\alpha_{5,1}$	0.1571***	0.0049*	$\beta_{5,1}$	0.2298*	-43.3532***
	(0.0555)	(0.0029)		(0.0985)	(13.7437)
$\alpha_{1,2}$	0.1850	-0.0136	$\beta_{1,2}$	0	0
	(0.1654)	(0.0091)		-	-
$\alpha_{2,2}$	-0.0455**	-0.0058***	$\beta_{2,2}$	1	1
	(0.0219)	(0.0009)		-	-
$\alpha_{3,2}$	-0.1663***	-0.0172	$\beta_{3,2}$	-0.3195***	7.4157***
	(0.0487)	(0.1723)		(0.0441)	(0.7874)
$\alpha_{4,2}$	-0.0448*	0.0007	$\beta_{4,2}$	4.6891***	93.0824
	(0.0273)	(0.0016)		(0.5285)	(32.9326)
$\alpha_{5,2}$	-0.3749*	-0.0083*	$\beta_{5,2}$	0.0481*	-43.3532***
	(0.2031)	(0.0051)		(0.0263)	(7.7460)

Notes. This table presents estimates of vectors α and β described in *(12)*. As these two samples include two cointegration relations, α and β both become (5x2) matrices instead of (5x1) vectors, as it is the case in Australia and Canada without including the trade balance. The interpretation of the parameters remains unchanged.

F. Alternative specification for New Zealand using world commodity prices

The change of commodity prices measure did not alter the optimal lag structure or number of cointegration relations. The estimated model is thus identical to the one presented earlier for New Zealand (see section 4.4.4.3.), the only difference being that the domestic ANZ Bank index has been replaced by the IMF primary commodity prices index, which represents world commodity prices.

Impact of world commodity prices as measured by the IMF primary commodity prices index (IMF Pt), on New Zealand's fundamentals and real exchange rates, 1986 Q1 – 2012 Q3:



Notes. See **Figure 4.**

Chapitre 5 : conclusion

Ce mémoire cherche à identifier si le lien établi entre cours des matières premières et cours des monnaies liées aux matières premières provient de l'effet de ces cours sur les fondamentaux macroéconomiques des pays concernés, ou s'il provient d'une demande spéculative pour ces monnaies. Trois devises sont étudiées, les dollars australien, canadien et néo-zélandais, en utilisant des données trimestrielles et mensuelles lors de tests de robustesse.

Les effets des fondamentaux macroéconomiques et de la spéculation sur le taux de change réel de ces pays sont étudiés à l'aide d'un SVECM. Ce type de modèle prend en compte les relations de cointégration qui sont fréquentes entre séries macroéconomiques de long terme, tout en permettant une interaction contemporaine des variables étudiées : le cours des matières premières locales, le niveau des prix à la consommation, le PIB réel, les taux d'intérêts réels et le taux de change réel. Plus précisément, ces effets fondamentaux et spéculatifs sont séparés en décomposant la réponse du taux de change réel à un choc dans le prix des matières premières. Nous montrons que cette réponse est une fonction de l'effet des matières premières sur les cinq variables incluses dans notre modèle. La partie de cette réponse qui ne dépend que de la variation du prix des matières premières constitue l'effet direct du choc qui, comme il ne dépend pas des variables fondamentales, représente la partie spéculative de la réponse. La partie expliquée par l'effet des matières premières sur les autres variables du modèle (niveau des prix à la consommation, PIB réel, taux d'intérêts réels et valeurs passées du taux de change réel) constitue l'effet indirect du choc, qui représente la partie fondamentale de la réponse.

Le résultat principal de ce mémoire provient de la décomposition de la réponse du taux de change réel suite à un choc dans le prix des matières premières en deux effets, l'un fondamental et l'autre spéculatif. Cette séparation donne des résultats probants et similaires dans tous nos échantillons. Au moment du choc, l'appréciation réelle du taux de change constatée s'explique presque entièrement par l'effet spéculatif, qui semble capturer des anticipations relatives aux valeurs futures du taux de change. A partir d'un trimestre après le choc, l'appréciation réelle s'explique principalement par l'effet fondamental, ce qui reflète l'influence effective du cours des matières premières sur les économies nationales. Nos résultats suggèrent également que le dollar néo-zélandais est plus sujet à spéculation que ses équivalents australien et canadien : l'effet spéculatif apparait plus durable dans le cas de la Nouvelle-Zélande, et le taux de change réel du pays répond plus fortement au prix des matières premières mondiales qu'à celui des matières premières locales. Du fait de la faible persistance de l'effet spéculatif dans tous les échantillons étudiés, l'on peut estimer que le lien entre matières premières et monnaies liées aux matières premières résulte principalement d'un effet fondamental des ressources naturelles sur les économies considérées.

Deux autres types de résultats sont présentés dans cette étude. Nous décomposons cet effet fondamental en ses quatre composantes : niveau des prix à la consommation, PIB réel, taux d'intérêts réels et valeurs passées du taux de change réel. Dans les cas de l'Australie et du Canada, l'effet fondamental est dominé par les réponses passées du taux de change. En d'autres termes, l'effet reflète la forte persistance des mouvements de taux de change suite à un choc dans le prix des matières premières. L'effet indirect en Nouvelle-Zélande est quant à lui influencé par un facteur supplémentaire, les prix à la consommation. Cela démontre que la hausse des prix à la consommation résultant d'une augmentation inattendue du prix des matières premières contribue à son tour à l'appréciation réelle du dollar néo-zélandais.

Enfin, nous constatons que le cours des matières premières a un effet significatif sur le taux de change réel et les fondamentaux économiques des pays analysés, confirmant les résultats de la littérature empirique. Un choc dans le cours des matières premières nationales influence le taux de change réel, les prix à la consommation et les taux d'intérêts réels à un niveau de confiance de 95% dans les trois pays sélectionnés. Cependant, le PIB réel n'est significativement affecté qu'au Canada.

Cette analyse pourrait être étendue dans de futurs travaux. Nous n'avons considéré que des chocs positifs dans le prix matières premières, alors qu'une étude étudiant à la fois des chocs positifs et négatifs pourrait mettre en avant les effets asymétriques de ces chocs, aussi bien sur le taux de change que sur les fondamentaux économiques. De plus, les taux de change et le cours des matières premières étant des séries financières, prendre en compte les variations de leur volatilité dans le temps à l'aide de modèles de type Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) conduirait à des estimations plus précises.