Commodity currencies and equity flows

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Abstract

This paper analyzes the relationship among the prices of natural resources, returns on equity and nominal exchange rates of the developed countries where primary commodities are an important share of exports: Australia, Canada and New Zealand. It is found that the portfolio rebalancing motive of Hau and Rey [2006. Exchange rates, equity prices, and capital flows. Review of Financial Studies 19 (1), 273-317] is weaker for these countries. One possible explanation of this finding is that commodity prices due to their flexibility play a special role in the transmission of shocks by linking equity markets across countries and reducing the need for portfolio rebalancing.

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1. Introduction

Commodity currencies are currencies of countries where primary commodities (natural resources) constitute an important share of exports. There is a large empirical literature looking at the relationship between the prices of primary commodities and the values of real and nominal exchange rates for commodity exporting countries (Amano and van Norden, 1995; Chen and Rogoff, 2003; Cashin et al., 2004). The theoretical justification for the link comes from trade in goods. Booming commodity prices represent terms of trade improvements that can be viewed as a transfer of wealth from commodity importing to commodity exporting countries. These transfers of wealth can affect the nominal exchange rate directly as in Engel (2005) or they can affect the real exchange rate through the relative price of nontraded goods as in Dornbusch (1980), Edwards (1989), and Neary (1988).

Hau and Rey (2006) provide theoretical microfoundations for the relationship between equity markets and exchange rates based on portfolio rebalancing. In their model, portfolio managers invest in domestic and foreign equities. Foreign exchange rate risks are not hedged which is consistent with recent surveys of institutional investors in Levich et al. (1999). Portfolio managers hold equity risks and exchange rate risks as a bundle. A portfolio can deviate from the desirable portfolio due to unexpected shocks. One such shock is an exogenous shock to equity returns. If a foreign equity market outperforms the domestic market, a share of foreign equity increases in the portfolio. The portfolio is now overexposed to exchange rate risk. Domestic investors find it optimal to withdraw a portion of investment from the foreign equity market. Equity outflows from the foreign market lead to an appreciation of the domestic currency. The model implies that stronger equity markets are associated with weaker currencies. Hau and Rey (2006) test the implications of the model for 17 OECD countries and find strong support for the presence of the portfolio rebalancing motive in the data. Canada and New Zealand were not included in the analysis.

In this paper I extend the analysis of Hau and Rey (2006) to commodity-producing coun-

tries with well-developed equity markets: Australia, Canada, and New Zealand[1]. Using correlations between equity returns, equity flows and exchange rates as in Hau and Rey (2006), I find that the portfolio rebalancing motive is weaker in these countries. The conclusion does not change when I condition commodity prices out. To give the portfolio rebalancing story the most favorable support from data and also to access the possibility of simultaneous bias in the results, I use a structural vector autoregressive model (VAR) in which sign restrictions implied by the portfolio rebalancing story as in Hau and Rey (2004) are used to identify structural shocks. The magnitudes of responses from this VAR are compared to single equation regressions. The comparison implies that the portfolio rebalancing story is not supported for commodity-producing countries. One possible explanation of these findings is that commodity prices make equity returns in commodity-producing countries highly correlated with the rest of the world. Due to this high correlation, there is no need to rebalance portfolios. This role of commodity prices may be similar to the role played by terms of trade in risk sharing (Cole and Obstfeld, 1991; Zapatero, 1995; Pavlova and Rigobon, 2007). What makes commodity-exporting countries different from other countries is that commodity prices are flexible while other prices are not. Therefore, the portfolio rebalancing motive is weaker in Australia, Canada, and New Zealand because their terms of trade are more flexible than in other countries.

The paper proceeds as follows. Section 2 outlines the construction of data. Section 3 presents simple correlations among exchange rate, equity, and commodity returns. Section 4 formally identifies structural shocks. Section 5 concludes.

2. Data

[1]Another two OECD countries that may be potentially included into the list of commodity-producing countries with well-developed equity markets are Finland and Norway. Oil is an important export for Norway, while forestry products account for a significant share of exports for Finland. These countries, however, have operated mostly under managed exchange rate regimes and therefore are not included in the analysis.

The data on equity flows come from the Treasury International Capital System (TIC) data provided by the U.S. Treasury. The TIC data provide monthly gross sales by domestic investors to U.S. residents and gross purchases by domestic investors from U.S. residents of U.S. and domestic stocks[2]. Flow is the difference between the former and the latter. A positive flow means that there is an inflow of capital into the domestic country or, consequently, an outflow from the United States. Since the volume of equity flows has increased dramatically, I adjust the net flow by the average of absolute flows over the previous 12 month as in Hau and Rey (2006). The domestic markets in this study are equity markets in Australia, Canada, and New Zealand.

The returns on equity are calculated using MSCI indexes for the three countries and the United States. I take the logs of the indexes and calculate monthly differences. All returns are measured in local currency. Finally, I calculate the relative return on domestic equity as the difference between domestic and U.S. returns.

The nominal exchange rate data are taken from IMF International Financial Statistics. The exchange rates are U.S. dollar prices of domestic currencies at the end of month. Therefore, the domestic currency appreciates when the exchange rate moves up. The return on domestic currency is calculated as the log difference of the monthly exchange rate.

Finally, the returns on commodity prices are calculated as the log difference of corresponding monthly commodity price indexes measured in U.S. dollars. The commodity price index for Canada is the total index including energy and non-energy commodities calculated by the Bank of Canada and available from Statistics Canada. The commodity price index for New Zealand is non-energy price index taken from the Australia and New Zealand Banking Group.[3] The total commodity price index for Australia is from the Reserve Bank of Australia.

[2]By domestic I mean non-U.S. throughout the paper.

[3]Energy is not an important component of exports for New Zealand.

3. Correlation structure

In this section, I have a preliminary look at the data. First, I evaluate the importance of primary commodities for equity markets and exports in the three commodity-exporting countries. While primary commodities play an important role in these countries, there are some significant differences. These differences have some bearing on the results in the later sections of the paper. Then, I look at simple correlations among equity returns, equity flows, exchange rate returns and commodity returns. Such correlations provide a simple way to identify differences between commodity and non-commodity currencies with respect to commodity price shocks and equity flows. I also look at correlations between equity returns, exchange rate returns and equity flows while conditioning on commodity returns by means of simple regressions. Such regressions are expected to be biased because the variables are endogenous. While there is no conclusive way to identify shocks in a system containing equity, exchange rate returns and equity flows, the next section attempts to address the issue by using sign restrictions.

Primary commodities constitute an important share of exports for Australia, Canada and New Zealand. The main primary commodity exports for Australia are coal, crude oil, gold, and wool. Canada specializes in crude oil, natural gas, pulp, and lumber. New Zealand exports meat and diary products among primary commodities (see Chen and Rogoff, 2003, Tables A.2 and A.3 for a more detailed listing). Figure 1 shows shares of primary commodities in total exports of goods based on OECD International Trade by Commodities Statistics for 2004. The total share of primary commodities is estimated at 47% for Australia, 24% for Canada, and 45% for New Zealand. These shares have decreased since the 1980s mainly because exports of other goods have increased. The figure shows that Australia has roughly equal shares of energy and non-energy exports. Canada has a higher share of energy exports, with non-energy primary commodities exports accounting for approximately 8%. New Zealand, in contrast, has a very low share for energy exports.

[Insert Figure 1 here]

Figure 2 considers the importance of energy and materials for the equity markets in the three countries. Here, Canada is ahead of the other two countries as energy and materials firms account for approximately 41% of equity market capital. Australia and New Zealand have lower shares at approximately 27%. In terms of energy and non-energy breakdown, the Australian stock market has a higher share in materials, while the Canadian stock market has a higher share in energy. New Zealand's stock market has roughly equal shares in materials and energy.

Figures 1 and 2 show that Canada has a different status from Australia. Primary commodities have a higher share in exports for Australia than for Canada, while Canada has a higher share of energy and materials in the stock market. These findings will have some bearings on results of the next section.

[Insert Figure 2 here]

How can equity markets and exchange rates be related? Hau and Rey (2006) provide a model that highlights one aspect of this relationship. Surveys in Levich et al. (1999) indicate that only 8% of equity investments are hedged for exchange rate risk. Instead, investors handle exchange rate risks and equity risks as a bundle. Suppose we start from an equilibrium where all portfolios are optimal. If there is an unexpected positive shock to the foreign equity market, the share of foreign equity in the portfolios increases and this increase makes the portfolios more risky as they are exposed to more exchange rate risk. In such a situation, investors withdraw a portion of investment from the foreign equity market depreciating the foreign currency. There is a strong prediction from the model in Hau and Rey (2006): Exchange rate returns and relative equity returns are negatively correlated, while exchange rate returns and equity flows are positively correlated. Hau and Rey (2006) test these predictions for a set of OECD countries and find support for a

negative correlation between relative equity returns and exchange rate returns at monthly frequency for all countries except Australia from January 1990 to December 2001. New Zealand and Canada were not included in the analysis. The evidence on positive correlation between equity flows and exchange rate returns is not that strong over the same period. The correlation is positive for 11 out of 17 countries, but statistically significant for only five countries at the 1% level, and for one country at the 10% level. The correlation for Australia is negative.

Table 1 extends the analysis of correlation among equity flows, exchange rate and equity returns to Canada and New Zealand and for the periods up to November 2006. Part (a) shows that the correlation between equity and exchange rate returns starts positive over the 1980-2006 sample but then gradually turns to negative in more recent periods. The correlation for Australia is negative and statistically significant at the 1% level from 2000 to 2006. These developments are consistent with the increase in the importance of equity markets: As equity flows among countries increase, the correlation between equity returns and exchange rate returns becomes more negative. The last column shows the correlation results over the 1990-2001 period in order to compare the results with those in Hau and Rey (2006). Australia, Canada, and New Zealand all have positive correlations while non-commodity countries in Hau and Rey (2006) have negative correlations (Austria at -0.1998, Belgium-Luxembourg at -0.2569, Denmark at -0.2934, Finland at -0.2570, France at -0.3473, Germany at -0.2871, Ireland at -0.2805, Italy at -0.1312, Japan at -0.0276, Netherlands at -0.3689, Norway at -0.1787, Portugal at -0.1341, Spain at -0.2183, Sweden at -0.2862, Switzerland at -0.1761, and U.K. at -0.2778 from Hau and Rey, 2006, Table 3.)

[Insert Table 1 here]

What makes the commodity currencies an exception to the rule that relative equity returns and exchange rate returns are negatively correlated? While the correlations turn to

negative in the last 2000-2006 period in Table 1(a) it is obvious that the commodity currencies are lagging behind other developed countries. Models in Cole and Obstfeld (1991), Zapatero (1995) and Pavlova and Rigobon (2007) may shed some light on this puzzling behavior. These models assign an important role to terms of trade in pooling risks. Consider two countries that have no trade in goods, but trade in equities. If there is a positive output shock in one of the countries, its stock market outperforms the stock market in the other country since equity is a claim on domestic output. Foreign investors would withdraw a portion of equity investments from the booming country since their portfolios are overexposed to exchange rate risk as in Hau and Rey (2006). These equity flows would cause the other market to perform better and the exchange rate of the booming economy to depreciate. Now consider the same two countries but assume that they trade in goods. As in Pavlova and Rigobon (2007), a positive output shock increases returns on equity and worsens terms of trade. Through terms of trade, the shock is transmitted to the other country where it causes the stock market to perform better and the exchange rate of the other country to appreciate. Since non-commodity prices are sticky, while commodity prices are known to be flexible, commodity prices may play an important role in the transmission of shocks and through this trasmission may weaken the need for the portfolio rebalancing motive. That is why commodity currencies may exhibit different patterns than non-commodity currencies.

Part (b) of Table 1 looks at the correlation between equity flows and exchange rate returns. The correlation is expected to be positive based on the portfolio-rebalancing motive: An equity inflow in the domestic market appreciates the domestic exchange rate. Other shocks, however, can mute this correlation. An unexpected depreciation of the domestic currency may cause equity outflow from the foreign equity market. In this case, the correlation between equity flows and exchange rates is negative. The overall sign of correlation depends on what shocks dominate. The table shows that the correlations are positive in most periods. However, they are not significant. If both exchange rate and equity return shocks

are equally important, the correlation is expected to be low. Another possibility exists: If equity markets move together due to terms of trade movements, portfolio rebalancing is not necessary and, therefore, the link between equity flows and exchange rates is going to be weak.

The last part of Table 1 shows the correlation between exchange rate returns and commodity returns. These correlations are positive and significant at different levels for all periods and countries except Canada in the 1990-2001 period. They support previous studies that find a link between commodity currencies and exchange rates (Amano and van Norden, 1995; Chen and Rogoff, 2003; Cashin et al., 2004).

The simple correlations in (a) and (b) of Table 1 may be misleading because of the presence of commodity price shocks. The portfolio rebalancing model implies that the correlation between equity returns and exchange rate returns is negative. Commodity price shocks, however, are expected to increase equity returns and to appreciate commodity currencies. Therefore, the correlation between equity and exchange rate returns conditional on commodity price shocks may be positive. If commodity price shocks dominate, the unconditional correlation may turn out positive as well. The same argument would apply to the correlation between exchange rate returns and equity flows which the portfolio rebalancing story suggests is positive. However, if commodity shocks cause equity outflows and an appreciation of the domestic currency, the correlation could be negative. It is important, therefore, to consider correlations conditional on commodity price shocks. I achieve this objective by considering simple regressions of exchange rate returns on equity and commodity returns in Table 2, and exchange rate returns on equity flows and commodity returns in Table 3.

The results in Table 2 are overall consistent with Table 1. While controlling for commodity price shocks, equity returns for the commodity countries have a negative impact on exchange rate returns as expected based on the portfolio rebalancing model. The negative impact of equity returns is, however, statistically significant only for Australia in the 2000-

2006 period. The results demonstrate that the unconditional correlation between equity returns and exchange rate returns is not dominated by commodity price shocks. Therefore, the results suggest that the correlation between the variables is weak because the portfolio rebalancing motive is weaker in these countries relative to non-commodity currencies.

[Insert Table 2 here]

Another way to test the portfolio rebalancing story is to look at the correlation between equity flows and exchange rates while controlling for commodity returns. Table 3 addresses this question for the three countries. The equity flow for New Zealand is available only since February of 2001. While the coefficients for the equity flow are positive in most cases as predicted by the portfolio rebalancing model, they are not significant. Conditioning on non-commodity price shocks does not make the correlation between equity flows and exchange rates statistically stronger. Therefore, I reach the same conclusion: The portfolio rebalancing motive seems to be weaker in commodity-producing countries.

[Insert Table 3 here]

It is of interest to see how the results would change at the quarterly frequency. It is expected that the portfolio rebalancing motive should become stronger as more portfolios can be rebalanced. Indeed, portfolio managers may have different horizons. Some would rebalance on a daily basis, while others may work at monthly, quarterly or even longer horizons. Table 4 shows that the results do not change much at the quarterly frequency. The coefficient for equity returns is negative and statistically significant only for Australia in the last period. It is negative for Canada, and positive for New Zealand, but in both cases it is not statistically significant. I consider the difference in the results at monthly and quarterly frequency as not economically significant. Therefore, the evidence in favor of protfolio rebalancing model does not strengthen at the quarterly frequency.

[Insert Table 4 here]

Low adjusted R^2 in the tables should not be viewed as suspicious, since the dependant variable is the exchange rate return at monthly or quarterly frequency. There is a large empirical literature showing that the exchange rate returns are not explainable at such horizons by macroeconomic fundamentals. I look at just two factors that may play a role in explaining exchange rate fluctuations. The adjusted R^2 is high for Australia over the whole sample. This is due to a traditionally high share of primary commodities in Australian exports.

The results in Tables 2 to 4 may be biased due to the simultaneous nature of equity and exchange rate returns, and equity flows. The next section tries to identify shocks to exchange returns, equity returns, and equity flows formally.

4. Identification of shocks

Equity returns, exchange rate returns, and equity flows are expected to be simultaneously determined. The portfolio rebalancing model implies that exogenous shocks to equity returns would cause equity flows that would in turn affect exchange rate returns. An exogenous shock to equity flows is expected to affect equity returns and exchange rates. Finally, exchange rate movements themselves can change a share of foreign equity in the portfolio and, therefore, can affect equity flows and returns. The three variables of interest are endogenous. The simple regressions in the previous section do not take into account a possibility of simultaneity.

To address the issue of simultaneity I develop a VAR model with the three endogenous variables and exogenous commodity returns. I search for the lag order of the VAR process from 2 to 12 lags. Both AIC and HQ criteria favour a parsimonious representation with 2 lags for the monthly data[4]. Commodity prices are treated as exogenous for the three small

[4]This is also the lag order chosen in Hau and Rey (2004).

open economies. This assumption is plausible since Australia, Canada, and New Zealand are small suppliers of commodities in the world market and they have no impact on the prices of their commodities (see further discussion in Amano and van Norden, 1995; Chen and Rogoff, 2003). Of course, economic conditions in the United States and the world economy are expected to affect commodity prices. That is, commodity prices may not be exogenous to exchange rates of these countries, because economic conditions in the United States or in the world may affect commodity currencies and commodity prices simultaneously. Amano and van Norden (1995) test for the exogeneity between commodity prices and the real exchange rate for Canada and find that commodity prices are exogenous. Chen and Rogoff (2003) use a broad world commodity price index as an instrument for country specific commodity price indices. This approach is supposed to deal with the endogeneity problem arising from market pricing power of commodity suppliers. The results do not change substantially indicating that Canada, New Zealand, and Australia may be treated as price takers for commodities they export. Another source of bias may arise due to global shocks: A booming world economy may push commodity prices up and appreciate commodity currencies. Chen and Rogoff (2003) argue that an independent effect from high world growth relative to growth in commodity-producing countries should depreciate commodity currencies. Since it is usually found that shocks to commodity prices appreciate the exchange rates of commodity-producing countries, the authors rule out concerns about this type of bias. In accordance with these findings, I treat commodity prices as exogenous.

The Wold MA representation of the system is

$$\mathbf{y}_t = \phi + \mathbf{D}(L)x_t + \mathbf{B}(L)\nu_t, \qquad \nu_t \sim (0, \Sigma)$$

where $\mathbf{y}_t$ is 3×1 vector of endogenous variables (exchange rate returns, equity returns, equity flow), x_t contains commodity returns, $\mathbf{D}$ and $\mathbf{B}$ are matrix polynomials in the lag order, and

ϕ is a constant. A structural decomposition with contemporaneously uncorrelated shocks should be of the form

$$\mathbf{y}_t = \phi + \mathbf{D}(L)x_t + \mathbf{C}(L)e_t, \qquad e_t \sim (0, I)$$

where $\mathbf{C}(L) = \mathbf{B}(L)\tilde{P}$, $e_t = \tilde{P}^{-1}\nu_t$ and $\tilde{P}$ is such that $\tilde{P}\tilde{P}' = \Sigma$. Any recursive ordering of variables is unlikely to result in a meaningful decomposition. Following Hau and Rey (2004), I impose sign restrictions on conditional correlations.

The conditional contemporaneous correlations between y_{it} and y_{jt} can be calculated from the MA representation in orthogonalized errors

$$\rho_{ji|s} = \frac{(\mathbf{C}^i(L)s)(\mathbf{C}^j(L)s)}{\sqrt{(\mathbf{C}^i(L)s)^2(\mathbf{C}^j(L)s)^2}}.$$

Three restrictions are imposed. First, an exchange rate shock is expected to produce a negative correlation between exchange rates and equity returns, and a positive correlation between equity returns and equity flows. This is because an unexpected appreciation of domestic currency should cause equity outflow and a fall in domestic returns. Second, a positive shock to equity returns is expected to produce a negative correlation between exchange rate and equity returns, and a positive correlation between exchange rate returns and equity flows. This is because an unexpected outperformance of the domestic equity market causes equity outflow and a depreciation of the domestic currency. Finally, a positive shock to equity flows is expected to cause a positive correlation between equity flows and equity returns, and between exchange rate returns and equity flows. Equity flows are expected to drive returns on the exchange rate and equity up. Table 5 summarizes the proposed identification.

[Insert Table 5 here]

The purpose of the proposed identification is to identify shocks in such a way that they are most favorable to the portfolio rebalancing story. Then, I use identified shocks to assess the importance of simultaneity bias in Tables 2 and 3. The comparison of the magnitudes in simple regressions and in the VAR shows that in order to explain the results in simple regressions I need two types of shocks to be dominant at the same time. Since it is not possible that the two shocks dominate at the same time, I treat this as an evidence that the portfolio rebalancing model is not supported for commodity exporting countries analyzed in this paper.

Formally, the identification is achieved by using Jacobi rotations $\mathbf{R}_{\theta_1}$, $\mathbf{R}_{\theta_2}$, $\mathbf{R}_{\theta_3}$, for $-\pi/2 < \theta_i < \pi/2$ and $i = 1, 2, 3$. The matrices are the following:

$$\mathbf{R}_{\theta_1} = \begin{pmatrix} cos(\theta_1) & -sin(\theta_1) & 0 \\ sin(\theta_1) & cos(\theta_1) & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad \mathbf{R}_{\theta_2} = \begin{pmatrix} cos(\theta_2) & 0 & -sin(\theta_2) \\ 0 & 1 & 0 \\ sin(\theta_2) & 0 & cos(\theta_2) \end{pmatrix},$$

and

$$\mathbf{R}_{\theta_3} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & cos(\theta_3) & -sin(\theta_3) \\ 0 & sin(\theta_3) & cos(\theta_3) \end{pmatrix}.$$

The matrix $\tilde{P}$ is $\mathbf{P}\mathbf{R}_{\theta_1}\mathbf{R}_{\theta_2}\mathbf{R}_{\theta_3}$, where $\mathbf{P}$ is the lower triangular matrix of the Choleski decomposition. Following Hau and Rey (2004), θ_1, θ_2, and θ_3 are chosen such that to minimize the sum of penalty terms $\sum_{k=1}^{6} f(k, \theta_1, \theta_2, \theta_3)$ where $f(k, \theta_1, \theta_2, \theta_3) = -\rho(k, \theta_1, \theta_2, \theta_3)$, if the correlation should be positive based on theoretical priors, and $f(k, \theta_1, \theta_2, \theta_3) = \rho(k, \theta_1, \theta_2, \theta_3)$, if the correlation is expected to be negative. The search for the rotation angles is implemented as a grid search with 90 uniformly distributed angles on the interval [-$\pi/2$, $\pi/2$] for each rotation angle. The proposed identification would result in impulse responses most favourable

to the theory. There are three angels to search for in order to satisfy six restrictions. Therefore, it is possible that such restrictions are rejected by the data if there is no orthogonal decomposition to satisfy all six restrictions at the same time.

Figure 3 shows impulse responses of the three endogenous variables to an identified exchange rate shock for Australia and Canada.[5] The models are estimated with monthly data from January of 1990 to November of 2006. This sample is chosen since equity flows were not important in the 1980s. A one standard deviation shock causes approximately 1.8% appreciation of the Australian dollar and 0.3% appreciation of the Canadian dollar. Such unexpected appreciations cause foreign investors to rebalance portfolios resulting in equity outflows. These outflows lead to a drop in relative equity returns. Equity returns fall by 0.9% in Australia, and by 0.6% in Canada.

[Insert Figure 3 here]

Figure 4 demonstrates an impact of an equity return shock. Such shocks have an equal impact on relative equity returns in Canada and Australia at 2.6%. Foreign investors withdraw a portion of their investment resulting in equity outflows. Equity outflows, in turn, lead to an exchange rate depreciation. The Australian dollar depreciates by 0.7% and the Canadian dollar depreciates by 0.4%. The impact of an equity return shock is temporary for Canada, as both exchange rate returns and equity flows becoming insignificant after two and four months, respectively.

[Insert Figure 4 here]

Figure 4 allows comparing the results of impulse responses assuming endogeneity with simple regressions in Table 2, which are based on the assumption that right hand side variables are exogenous, for the period from 1990 to 2006. In Table 2, a one standard deviation

[5]This type of analysis is not conducted for New Zealand since equity flows are available only starting in February of 2001.

shock to relative equity returns (2.6%) results in 0.08% appreciation of the Australian dollar, and in 0.03% depreciation of the Canadian dollar. There are two possible biases in the results of the simple regression in Table 2. On the one hand, an exchange rate shock is expected to decrease relative returns on equity. Ignoring such a possibility should result in a downward bias for the slope coefficient corresponding to the equity return in the simple regression of Table 2. On the other hand, an equity flow shock drives both equity returns and exchange rate returns up, so that the bias for the same coefficient in the simple regression of exchange rate returns on equity returns is upward. Figure 4, which is based on impulse responses most favorable to the portfolio rebalancing story, indicates that the Australian dollar depreciates by a much larger amount than in the table. The Canadian dollar appreciates in the table instead of depreciating. Such results point to a substantial upward bias in Table 2. This could be due to the importance of equity flow shocks during the period.

Figure 5 shows responses to an equity flow shock. Such a shock appreciates domestic exchange rates and increases relative equity returns. A one standard deviation shock leads to roughly 1.5% appreciation of the Canadian dollar and 1% increase in returns on Canadian equities. In Australia, exchange rate returns increase by 1.5% and equity returns by approximately 2.3%.

[Insert Figure 5 here]

The results in Table 3 for the slope coefficient corresponding to the equity flow are expected to be biased. The sign of the bias is ambiguous. This is because an equity return shock would cause equity outflows and an exchange rate depreciation. Therefore, the bias is expected to be positive in this case. An exchange rate shock drives the exchange rate return up and causes equity outflow. The bias is expected to be negative. The responses of the nominal exchange rate in Figure 5 are much stronger then in Table 3 for the period from 1990 to 2006. This could be due to a substantial downward bias due to exchange rate shocks

during the period.

I combine the results of discussions for Tables 2 and 3. The comparison of the IRFs and single equations implies that there is an upward bias in Table 2. This bias is possible if equity flows shocks dominate through the period. The same type of analysis for Table 3 shows that there is a downward bias in the table. This is possible if exchange rate shocks dominate through the period. Therefore, there is a conflict between these conclusions. It is not possible that both shocks dominate at the same period. On the other hand, it is possible to interpret the results of Tables 2 and 3 if the portfolio rebalancing model does not hold. If commodity prices play an important role in the transmission of shocks that cause equity returns to be perfectly correlated, there is no need to rebalance portfolios. In this case, the correlation between equity and exchange rate returns while conditioning on non-commodity shocks does not have to be strongly negative. The correlation between equity flows and exchange rate returns does not have to be strongly positive.

Figures 3 to 5 consider shocks to endogenous exchange rate and equity returns, and to equity flows. Figures 6 and 7 look at the impact of an exogenous commodity shock. Figure 6 shows impulse responses for Canada. I split the sample into two periods, before and after 1990, to show that the importance of commodity prices in explaining exchange rate and equity returns declines over time. A positive shock to commodity prices leads to an appreciation of the Canadian dollar and to an increase in returns on Canadian equity as was expected given the importance of primary commodities for the Canadian stock market and Canadian exports. The response of equity returns is persistent, while the response of exchange rate returns is temporary for Canada. Given that commodity price shocks appreciate the exchange rate and increase returns on domestic equity, one to expect equity outflows from Canada based on the portfolio-rebalancing motive. The impulse response functions show that the response of equity flows is insignificant. One interpretation of that finding is that commodity prices link equity returns across the markets and make portfolio

rebalancing unnecessary. An insignificance of the equity flow response is consistent with the model in Pavlova and Rigobon (2007). Their model has demand and supply shocks. Positive supply shocks (output shocks) drive returns on domestic equity since the stock market is a claim on domestic output. They also worsen terms of trade. The latter leads to an increase in foreign output and stock returns. Therefore, supply shocks cause stock markets to move together across countries. Positive demand shocks, on the other hand, improve terms of trade due to home bias in preferences towards domestically produced goods. They cause stock markets to diverge with domestic markets outperforming foreign markets. The model shows that terms of trade play an important role in the transmission of shocks across countries.

I interpret a positive shock to commodity prices as a positive supply shock. This is because demand shocks have an impact on the terms of trade only if there is a home bias in consumption. While home bias is reasonable for differentiated goods, it is not appropriate for homogenized goods such as lumber, wheat, aluminium and so on. The weight of such goods in the consumption baskets is likely to be the same across countries. Such a supply shock increases returns on foreign (U.S.) equity and through commodity prices is transmitted to Canada, where it appreciates the Canadian dollar and increases returns on Canadian equity. Such a shock is transmitted without affecting equity flows. Suppose we shut down this transmission mechanism. Higher returns on U.S. equity due to a positive supply shock would cause equity inflow into the Canadian equity market leading to an exchange rate appreciation and an increase in the returns on Canadian equity. Therefore, booming commodity prices allow this type of shock to be transmitted to Canada without affecting equity flows.

[Insert Figure 6 here]

Responses of variables to a positive shock to commodity prices for Australia is shown in Figure 7. Such a shock causes an appreciation of the Australian dollar and an increase in

relative equity returns. The difference from the responses for Canada is that the response of the relative equity return is not statistically significant at the 5% level. The responses of the equity flow are negative as expected based on the portfolio rebalancing channel. These responses are, however, again not significant. Statistical insignificance of the responses can give some support to the special role played by commodities in the transmission of shocks.

[Insert Figure 7 here]

To get further insights into the importance of commodity shocks for the endogenous variables, I construct forecast error variance decompositions in Table 6. The table shows that a commodity shock is more important for explaining forecast error variance of the exchange rate return than other variables for Australia. This is consistent with the finding from Figures 1 and 2 that primary commodities have a higher share in exports than in the stock market. In Canada, on the other hand, commodity shocks are more important in explaining the variance of equity returns. This is, again, consistent with Figures 1 and 2 since primary commodities have higher share in the Canadian stock market than in exports. An interesting result from Table 6 is that commodity shocks play no role in explaining equity flows. Since commodity shocks drive equity returns and appreciate the domestic currency, one would expect a strong impact on equity flows from the portfolio rebalancing point of view. The absence of such flows indicate the importance of commodity prices in linking equity markets.

Table 6 also shows that the importance of commodity prices for exchange rates and equity markets in commodity-producing countries declines over time. This is could be due to a decline in relative shares of primary commodities in exports and production in these countries. As primary commodities' share in exports and production declines over time, one can expect that the portfolio rebalancing motive would increase in importance. The evidence on negative correlations between equity and exchange rate returns in the last six years for the

commodity-producing countries may be an indication that the portfolio-rebalancing motive gets stronger.

[Insert Table 6 here]

5. Conclusions

This paper analyzes the portfolio rebalancing motive of Hau and Rey (2006) for commodity-exporting countries such as Australia, Canada, and New Zealand. The portfolio rebalancing model implies that in the world of unhedged exchange rate risks portfolios are rebalanced in response to unexpected shocks to dividends. If a foreign equity market outperforms the domestic market, a portfolio has a higher share of foreign equity and therefore is overexposed to exchange rate risks. Under such circumstances it is optimal to withdraw a portion of investment from the foreign equity market. Such equity outflows appreciate the domestic currency and increase returns on domestic equity. The model implies that equity returns and exchange rate returns are negatively correlated, while equity flows and exchange rate returns are positively correlated. Hau and Rey (2006) find strong empirical support for these predictions for most OECD countries over the sample from 1990 to 2001. However, in this paper, the correlation between equity returns and exchange rate returns is positive for Australia, Canada, and New Zealand over the same period. The correlation between equity flows and exchange rate returns is not significant for any of the three countries in any period. Therefore, the predictions of the portfolio rebalancing model are not supported for these commodity currencies.

I argue that this finding can be explained by a role played by commodity prices in the transmission of shocks. A positive supply shock in the U.S. that affects U.S. equity returns positively is transmitted to commodity-exporting countries through commodity prices. Booming commodity prices drive domestic equity returns up and appreciate commodity currencies. Therefore, commodity prices reduce the need to rebalance portfolios, since equity

markets move together. This argument is similar to Pavlova and Rigobon (2007), Cole and Obstfeld (1991) and Zapatero (1995) who show that terms of trade reduce the benefits of portfolio diversification. What makes commodity-exporting countries different from other countries is that commodity prices are flexible while other prices are sticky. Terms of trade movements may play a limited role in pooling risks at daily or monthly frequencies for most countries because of this price stickiness.

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Figure Legends

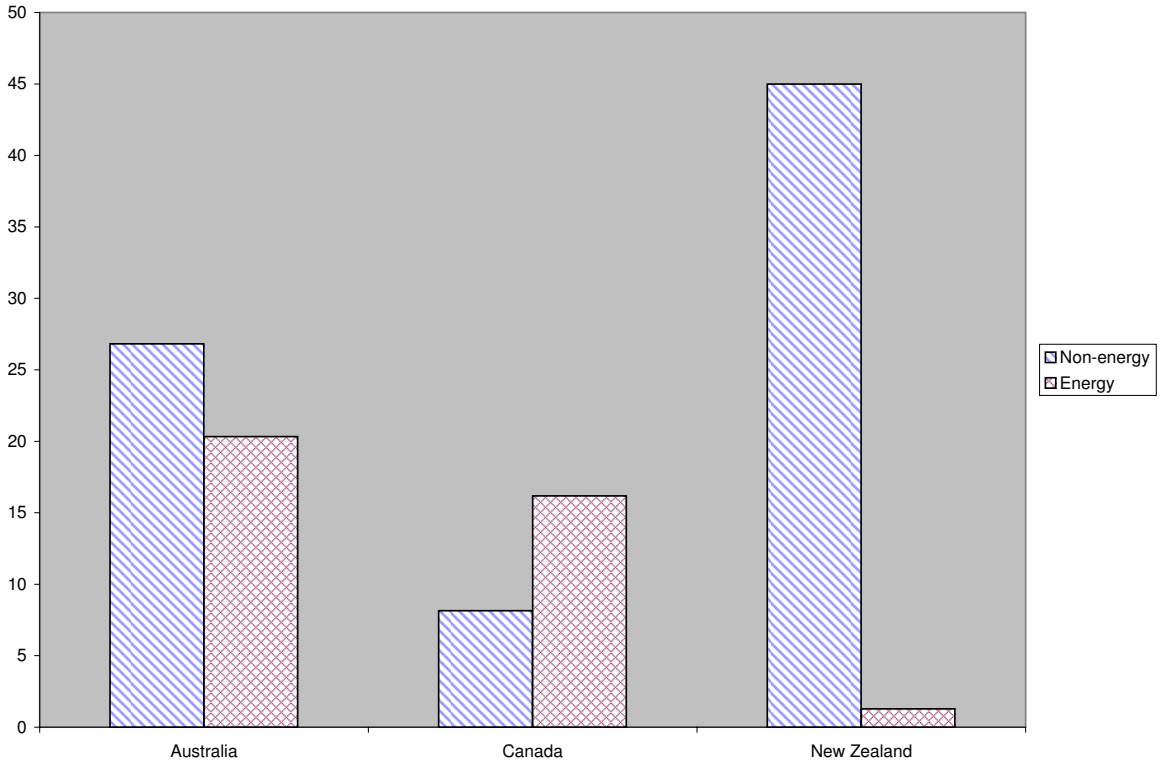

Fig. 1. Shares of primary non-energy and energy commodities for Australia, Canada, and New Zealand based on OECD International Trade by Commodities Statistics for 2004. Author's calculations.

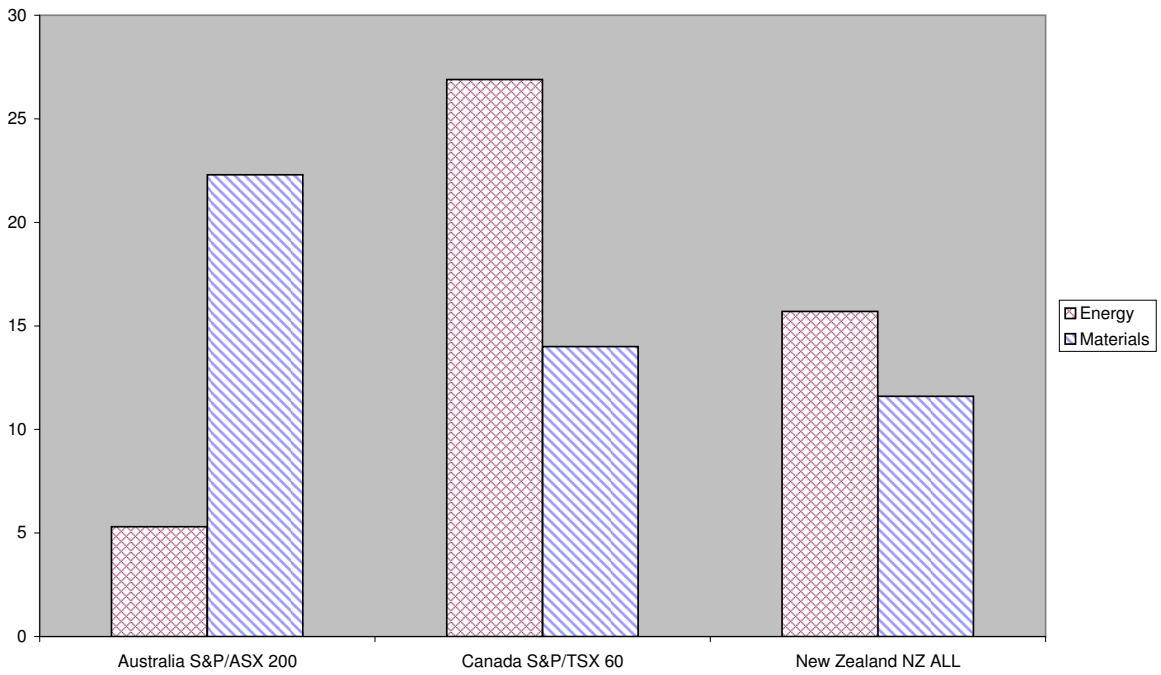

Fig. 2. Shares of energy and materials in stock markets for Australia, Canada, and New Zealand. Author's calculations.

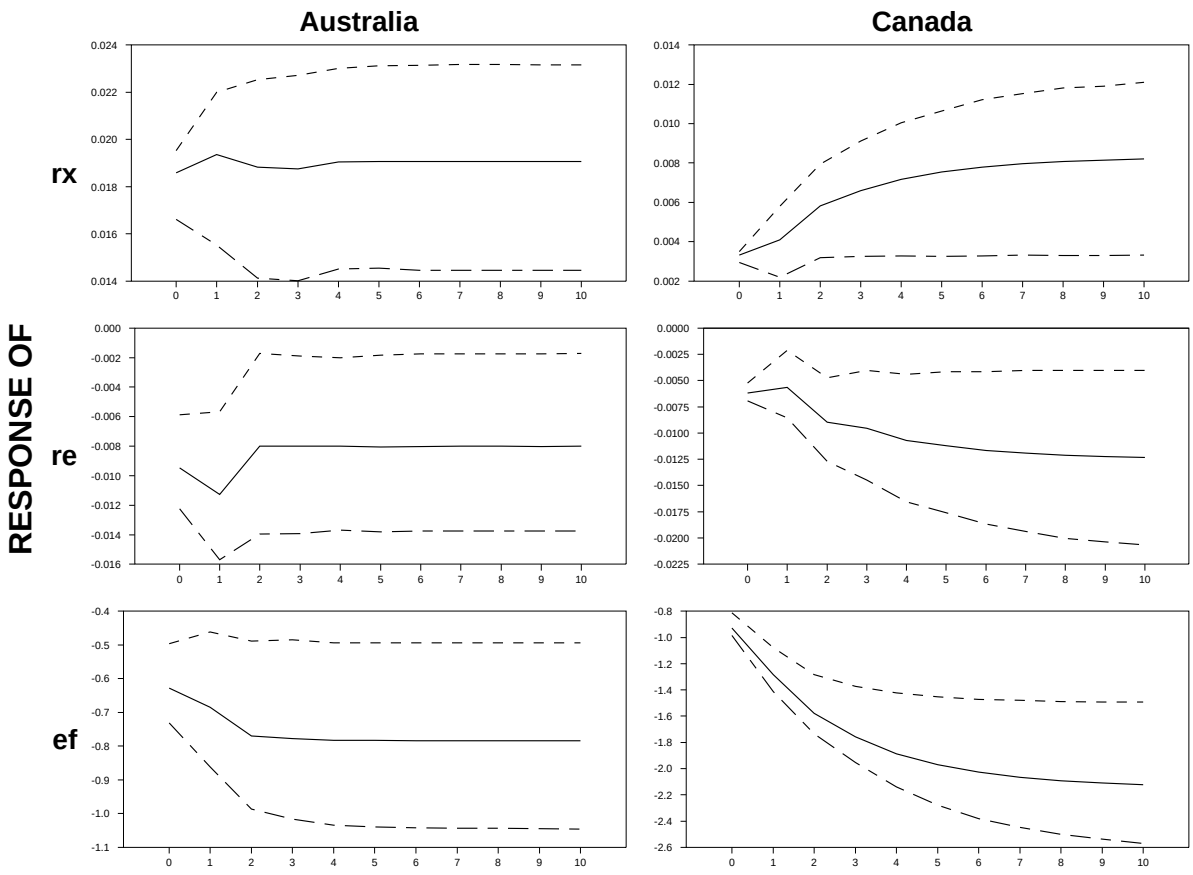

Fig. 3. Accumulated impulse responses of variables to an exchange rate shock. Variable *rx* is the exchange rate return (positive return means appreciation of the local currency), *re* is the return on local equity relative to the United States, and *ef* is the equity inflow into the domestic equity market. Monthly data from January 1990 to November 2006 are used to estimate a VARX model with two lags of endogenous and exogenous variables. Structural shocks are identified by using sign restrictions on conditional correlations. 95% confidence intervals are constructed by parametric bootstrap replications assuming normally distributed errors.

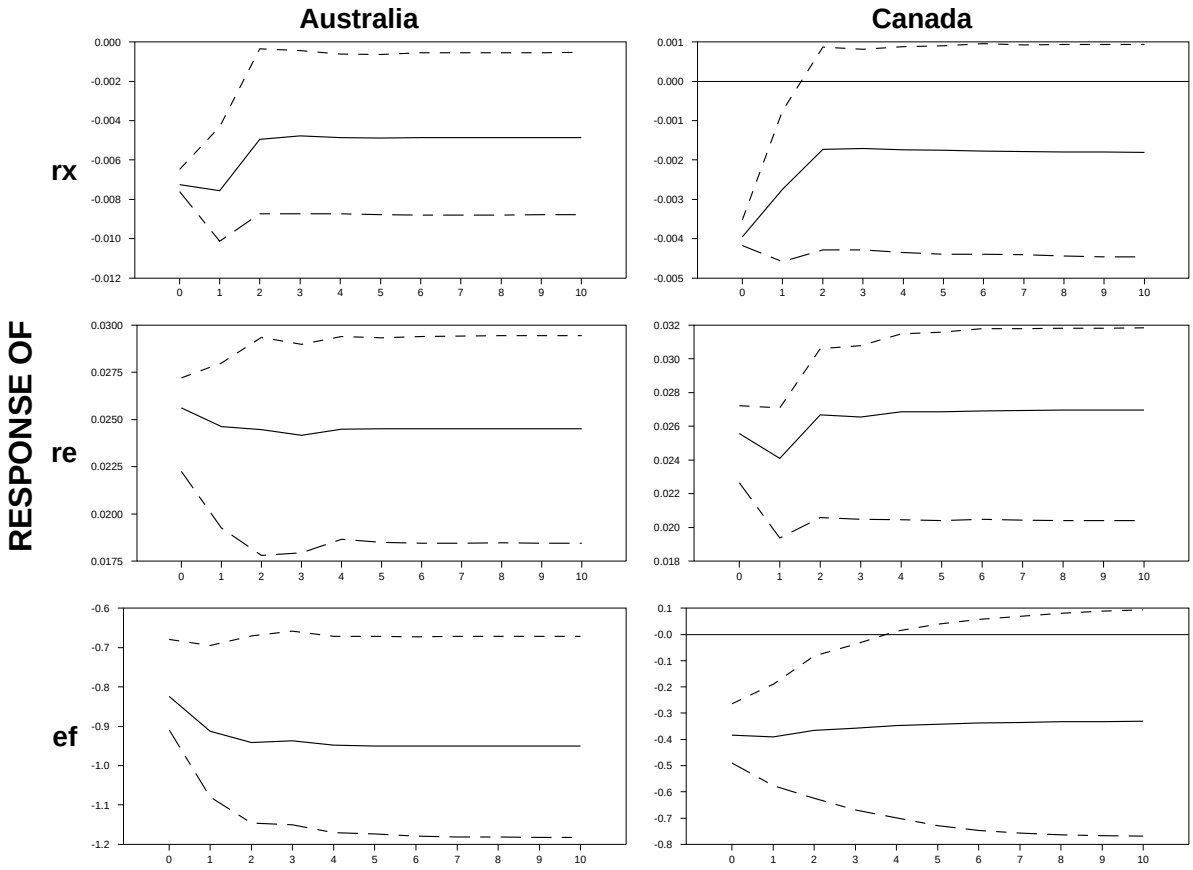

Fig. 4. Accumulated impulse responses of variables to an equity return shock. Variable *rx* is the exchange rate return (positive return means appreciation of the local currency), *re* is the return on local equity relative to the United States, and *ef* is the equity inflow into the domestic equity market. Monthly data from January 1990 to November 2006 are used to estimate a VARX model with two lags of endogenous and exogenous variables. Structural shocks are identified by using sign restrictions on conditional correlations. 95% confidence intervals are constructed by parametric bootstrap replications assuming normally distributed errors.

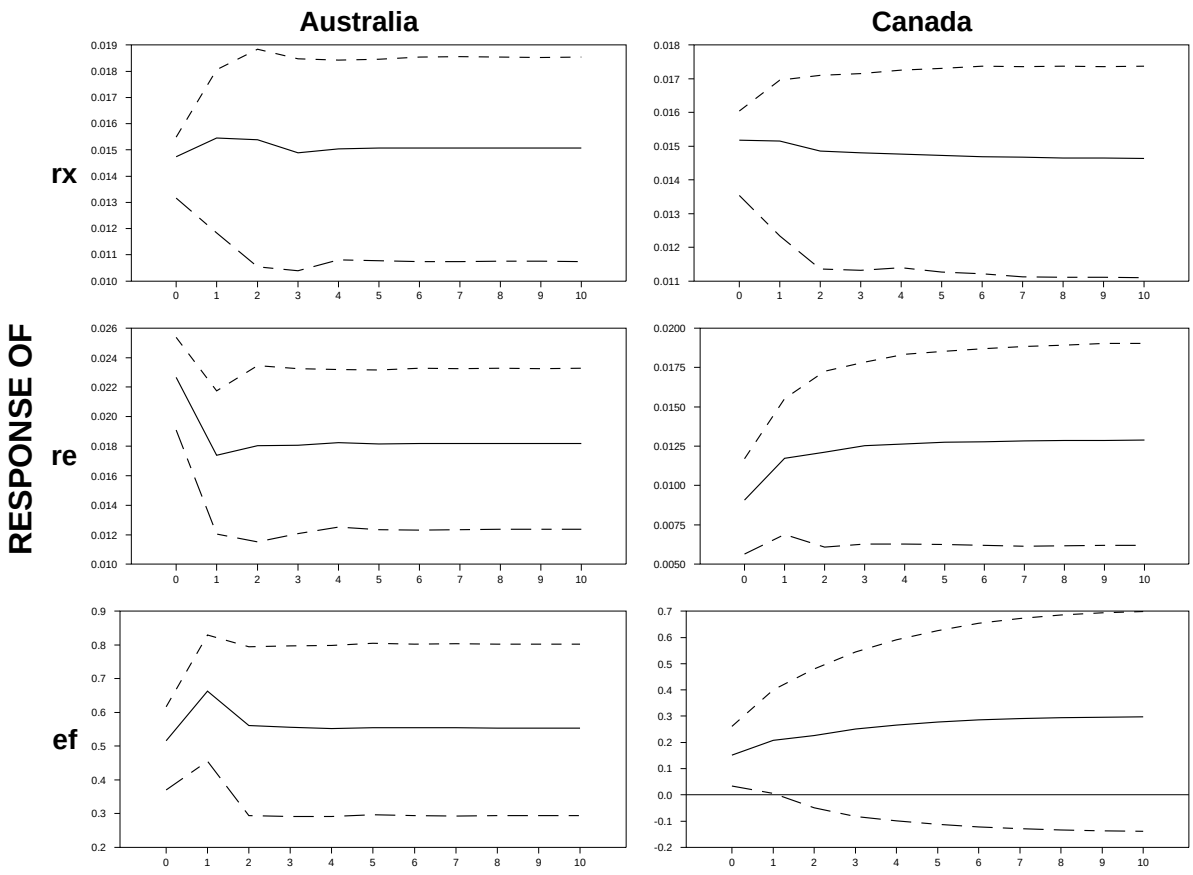

Fig. 5. Accumulated impulse responses of variables to an equity flow shock. Variable *rx* is the exchange rate return (positive return means appreciation of the local currency), *re* is the return on local equity relative to the United States, and *ef* is the equity inflow into the domestic equity market. Monthly data from January 1990 to November 2006 are used to estimate a VARX model with two lags of endogenous and exogenous variables. Structural shocks are identified by using sign restrictions on conditional correlations. 95% confidence intervals are constructed by parametric bootstrap replications assuming normally distributed errors.

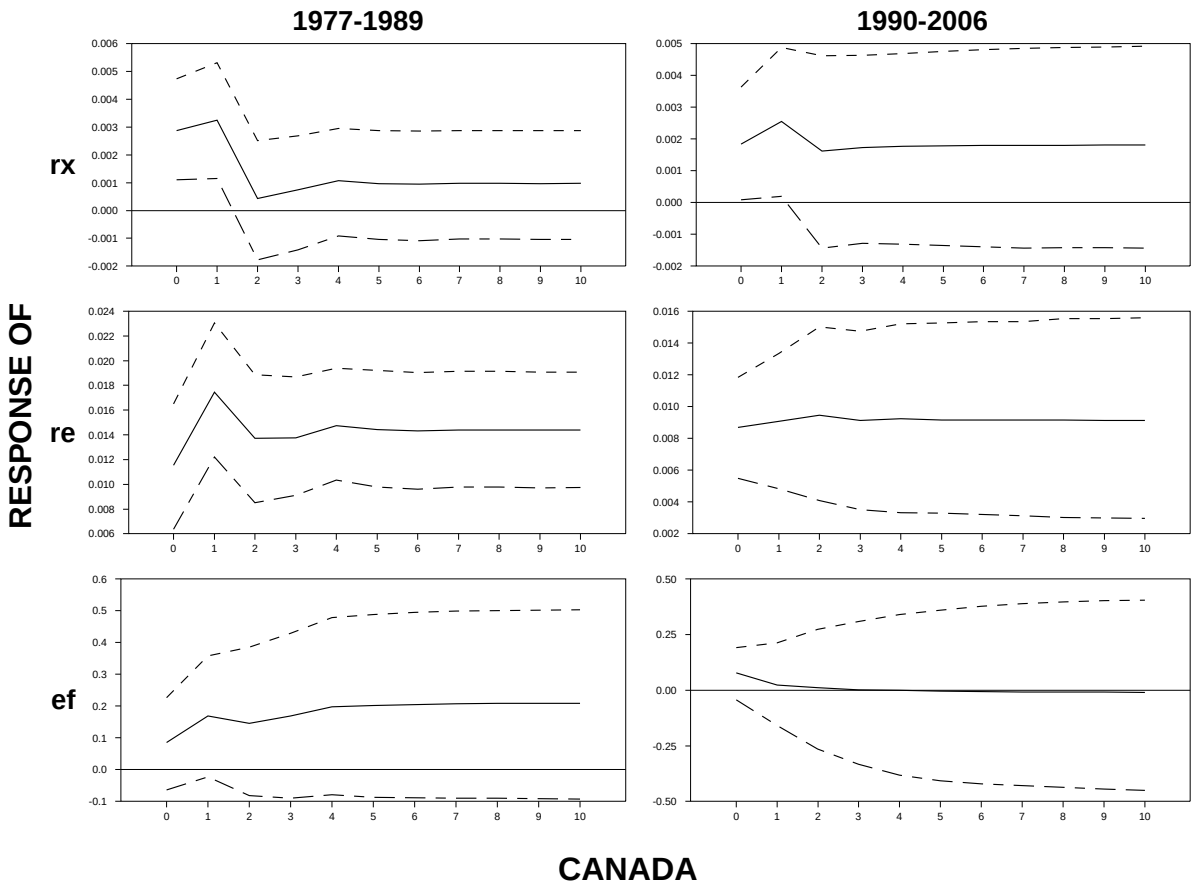

Fig. 6. Accumulated impulse responses of variables to a commodity return shock for Canada for two periods. The first column is for data from April 1977 to December 1989, and the second column is from January 1990 to November 2006. Variable *rx* is the exchange rate return (a positive return means an appreciation of the Canadian dollar), *re* is the return on Canadian equity relative to the United States, and *ef* is the equity inflow into the Canadian equity market. 95% confidence intervals are constructed by parametric bootstrap replications assuming normally distributed errors. Actual commodity returns are used in simulations.

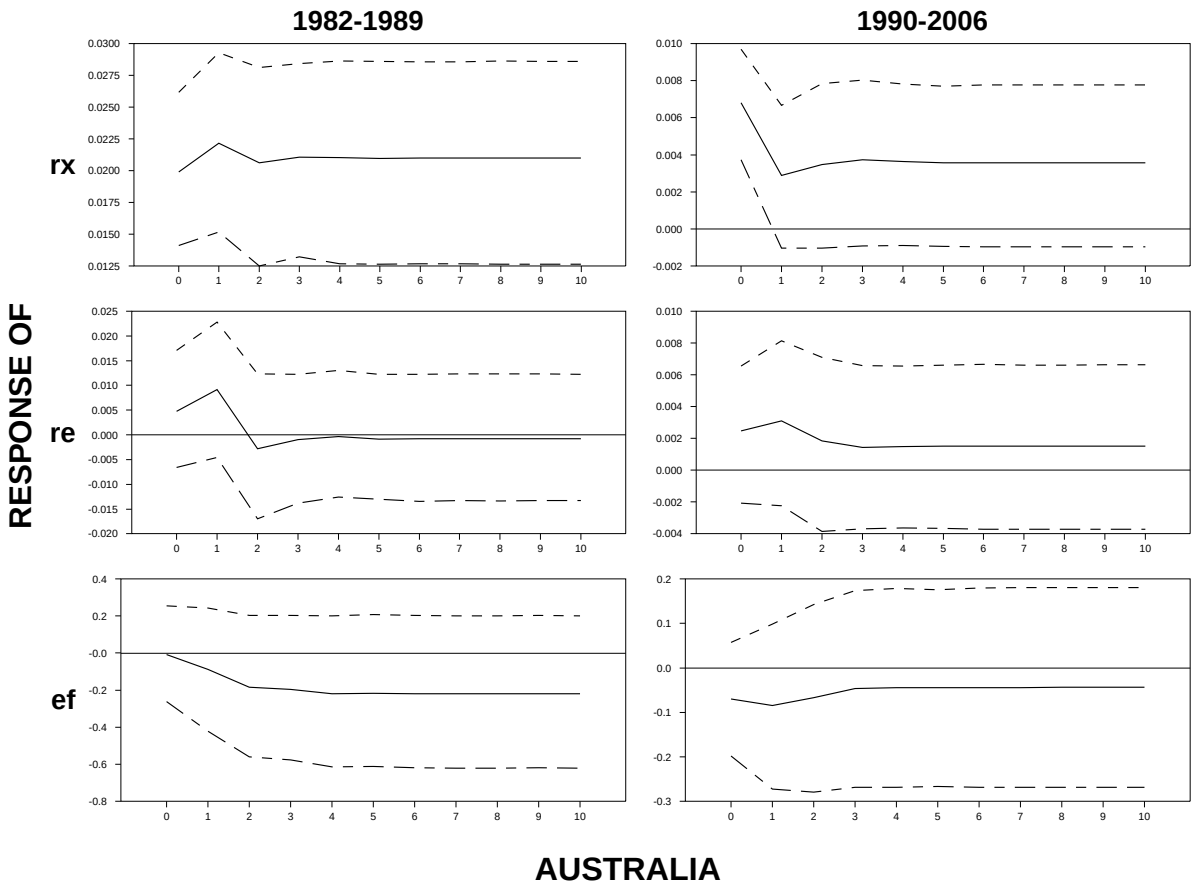

Fig. 7. Accumulated impulse responses of variables to a commodity return shock for Australia for two periods. The first period is from October 1980 to December 1989, and the second period is from January 1980 to December 2006. Variable *rx* is the exchange rate return (a positive return means an appreciation of the Australian dollar), *re* is the return on Australian equity relative to the United States, and *ef* is the equity inflow into the Australian equity market. 95% confidence intervals are constructed by parametric bootstrap replications assuming normally distributed errors. Actual commodity returns are used in simulations.

Tables

Table 1: Monthly correlations of exchange rate, equity and commodity returns, and equity flows

	Jan 1980 - Nov 2006	Jan 1990 - Nov 2006	Jan 2000 - Nov 2006	Jan 1990 - Dec 2001
	(a) Correlations of exchange rate and equity returns			
Australia	0.1494***	-0.0356	-0.2282***	0.0157
Canada	0.1551***	0.0637	-0.0191	0.0966
New Zealand	0.0132	0.0652	-0.1320	0.1156
	(b) Correlations of exchange rate returns and equity flows			
Australia	0.0639	0.0569	0.1310	-0.0148
Canada	0.0142	-0.0192	0.0410	0.0318
New Zealand			-0.0558	
	(c) Correlations of exchange rate and commodity returns			
Australia	0.3624***	0.2500***	0.2404***	0.2163***
Canada	0.1517***	0.1477**	0.1914*	0.0966
New Zealand	0.3090***	0.2125***	0.2309**	0.1347*

Asterisks *,**,*** mean significance at 10%, 5%, and 1% levels respectively. Returns are calculated as log-difference of corresponding variables. Exchange rates are U.S. dollar prices of the corresponding currencies, i.e. a positive exchange rate return means a depreciation of the U.S. dollar. Commodity price indexes are country-specific and taken from Statistics Canada, the Reserve Bank of Australia, and the Australia and New Zealand Banking Group. Equity returns are relative to U.S. equity returns and are based on MSCI indexes. Equity flows are calculated using the TIC data provided by the U.S. Treasury. Equity flow data for New Zealand start in February 2001 only. See Section 2 for more details.

Table 2: Regression of monthly exchange rate returns on equity and commodity returns

Country	α	β	γ	Sample	Adjusted R^2
Australia	-0.0021	0.0743*	0.6182***	1982:08 - 2006:11	0.1392
	(0.0017)	(0.0419)	(0.1316)		
	-0.0011	-0.0302	0.3993***	1990:01 - 2006:11	0.0549
	(0.0018)	(0.0515)	(0.1238)		
	-0.0000	-0.1805**	0.3703*	2000:01 - 2006:11	0.0730
	(0.0040)	(0.0858)	(0.1961)		
Canada	-0.0005	0.0426	0.0636**	1977:02 - 2006:11	0.0246
	(0.0008)	(0.0284)	(0.0280)		
	-0.0001	0.0132	0.0672**	1990:01 - 2006:11	0.0126
	(0.0011)	(0.0436)	(0.0332)		
	0.0025	-0.0656	0.0992**	2000:01 - 2006:11	0.0210
	(0.0022)	(0.0887)	(0.0480)		
New Zealand	-0.0001	-0.0053	0.4564***	1986:02 - 2006:11	0.0883
	(0.0019)	(0.0339)	(0.0961)		
	0.0004	0.0298	0.3394***	1990:01 - 2006:11	0.0386
	(0.0020)	(0.0472)	(0.1065)		
	0.0011	-0.0804	0.4998**	2000:01 - 2006:11	0.0413
	(0.0042)	(0.0998)	(0.2431)		

Asterisks *,**,*** mean significance at 10%, 5%, and 1% levels respectively. The regression of exchange rate returns, rx_t, on equity returns, re_t, and commodity returns, rc_t: $rx_t = \alpha + \beta\, re_t + \gamma\, rc_t + \epsilon_t$. Newey-West standard errors are reported. See the description of variables in Table 1 and Section 2 for more details.

Table 3: Regression of monthly exchange rate returns on equity flows and commodity returns

Country	α	δ	γ	Sample	Adjusted R^2
Australia	-0.0023	0.0021	0.6312***	1982:08 - 2006:11	0.1333
	(0.0017)	(0.0013)	(0.1336)		
	-0.0014	0.0015	0.4030***	1990:01 - 2006:11	0.0579
	(0.0018)	(0.0013)	(0.1226)		
	-0.0023	0.0028	0.4086**	2000:01 - 2006:11	0.0730
	(0.0038)	(0.0018)	(0.2000)		
Canada	-0.0005	0.0003	0.0772***	1977:02 - 2006:11	0.0170
	(0.0008)	(0.0007)	(0.0259)		
	-0.0001	- 0.0003	0.0703**	1990:01 - 2006:11	0.0124
	(0.0011)	(0.0010)	(0.0295)		
	0.0026	0.0008	0.0854**	2000:01 - 2006:11	0.0149
	(0.0023)	(0.0022)	(0.0373)		
New Zealand	0.0035	-0.0017	0.4439**	2001:02 - 2006:11	0.0215
	(0.0038)	(0.0021)	(0.2497)		

Asterisks *,**,*** mean significance at 10%, 5%, and 1% levels respectively. The regression of exchange rate returns, rx_t, on equity flows, ef_t, and commodity returns, rc_t: $rx_t = \alpha + \delta\ ef_t + \gamma\ rc_t + \epsilon_t$. Newey-West standard errors are reported. See the description of variables in Table 1 and Section 2 for more details.

Table 4: Regression of quarterly exchange rate returns on equity and commodity returns

Country	α	β	γ	Sample	Adjusted R^2
Australia	-0.0059	-0.0300	0.6223***	1982:4 - 2006:4	0.1652
	(0.0048)	(0.0684)	(0.1405)		
	-0.0042	-0.1379	0.5053***	1990:1 - 2006:4	0.0841
	(0.0058)	(0.1186)	(0.1907)		
	-0.0066	-0.2603*	0.5134**	1995:1 - 2006:4	0.0937
	(0.0087)	(0.1468)	(0.2423)		
Canada	-0.0019	0.0119	0.1199***	1977:2 - 2006:4	0.0518
	(0.0022)	(0.0550)	(0.0369)		
	-0.0001	-0.0097	0.1369***	1990:1 - 2006:4	0.0580
	(0.0031)	(0.0611)	(0.0402)		
	0.0015	-0.0463	0.1833***	1995:1 - 2006:4	0.0914
	(0.0036)	(0.0830)	(0.0461)		
New Zealand	0.0005	-0.0032	0.3797**	1986:2 - 2006:4	0.0595
	(0.0068)	(0.0602)	(0.1484)		
	0.0024	0.0578	0.2393	1990:1 - 2006:4	0.0127
	(0.0069)	(0.0863)	(0.1748)		
	0.0003	0.0162	0.3085	1995:1 - 2006:4	0.0003
	(0.0099)	(0.1421)	(0.2368)		

Asterisks *,**,*** mean significance at 10%, 5%, and 1% levels respectively. The regression of exchange rate returns, rx_t, on equity returns, re_t, and commodity returns, rc_t: $rx_t = \alpha + \beta\, re_t + \gamma\, rc_t + \epsilon_t$. Newey-West standard errors are reported. See the description of variables in Table 1 and Section 2 for more details.

Table 5: Identification of structural shocks

Shock	Correlation		
	Equity return and equity flow	Exchange rate and equity returns	Exchange rate return and equity flow
Exchange rate	+	–	
Equity return		–	+
Equity flow	+		+

Restrictions imposed on conditional correlations in order to identify structural shocks to exchange rate and equity returns, and equity flow.

Table 6: Forecast error variance decompositions for commodity shocks

Country	Period	Variance of		
		rx	re	ef
Australia				
	1982-1989	27.9%	4.2%	0.9%
	1990-2006	9.1%	0.6%	0.4%
Canada				
	1977-1989	9.5%	13.1%	1.4%
	1990-2006	1.8%	8.6%	0.7%

Contributions of commodity shocks in explaining forecast error variances of exchange rate returns, rx, equity flows, ef, and equity returns, re.