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Does the Canadian economy suffer from Dutch Disease?[1]

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Abstract

We argue that the failure to disentangle the evolution of the Canadian currency and energy and commodity prices from the US currency leads to potential wrong conclusions regarding the case of a Dutch disease in Canada. We propose a new approach aimed at extracting currency components and energy and commodity prices components from observed exchange rates and prices. Then, we analyze first the separate influence of commodity prices on the Canadian and the US currency component. Second, we estimate the separate impact of the two currency components on the shares of manufacturing employment in Canada. We show that 63 percent of the manufacturing employment loss due to exchange rate development between 2002 and 2007 are related to a Dutch disease phenomenon. The remaining 37 percent can be ascribed to the weakness of the US currency.

Keywords: Dutch disease; Natural resources; Exchange rates; Currency components; Bayesian Econometrics.

JEL classification: C11;F31;O13;O51

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Introduction

The Dutch disease refers to the case where a resource boom in an economy leads to a real exchange appreciation and to the crowding out of the tradable manufacturing sector. As put it by Krugman (1987), the interesting question is why should this phenomenon be regarded as a disease? According to Krugman, it becomes a disease when the manufacturing sector does not come back after the resource boom. Various forms of non-convexities are all good reasons why it might be the case. For instance, Krugman (1991) and Venables (1996) emphasize the idea of critical mass and suggest that there are levels below which further contraction of an industry is difficult to reverse. Furthermore, Krugman (1987) suggest that deindustrialisation might be detrimental in the long run for the whole economy since the manufacturing sector is characterized by learning by doing effects.

The underlying mechanism of the Dutch disease is that the real exchange rate of the resource rich economy tends to appreciate strongly with the rise of the export revenues from the resource sector. In turn, the appreciation harms the economy's exports from the manufacturing sector leading, over time, to de-industrialization.[2] The name of the phenomenon comes from a 1977 article in *The Economist* that described the shrinking of Netherlands' manufacturing sector following the discovery of important reserves in natural gas.[3]

Between 2002 and 2008, the spectacular rise in commodity and oil prices has led to an important development of the Canadian energy and commodity sectors. This is illustrated by the spectacular development of the Athabasca oil sand in the Northern part of the province of Alberta. While the extraction from oil sand is difficult and costly, the rise of the oil price to new high levels has triggered an important expansion of the extraction and export of the oil. This has in turn led to a big increase of Alberta nominal GDP per head, to a spectacular improvement of the provincial public finance and to important spillovers for the other provinces.[4] During the same period, the Canadian exchange rate appreciated and the manufacturing sector has contracted.

While the rise of the energy and commodity prices brings obvious benefits for Canada as a whole, it has raised also a lot of concerns of policy makers and economists. Most of those concerns are associated to the possibility that the Canadian economy is subject to the Dutch disease phenomenon. From the recently observed decrease in manufacturing employment, most of the analysts take nowadays for granted that the Canadian economy

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[2] Classical references on the Dutch diseases also include Corden and Neary (1982) and Corden (1984).

[3] The Dutch disease might be seen as one particular mechanism explaining the so-called natural resource curse, i.e. the observation that countries rich in natural resources tend to exhibit poor performances in terms of economic development. See on this among many others Sachs and Warner (1995, 1999), Gylfason (1999, 2001) and Stijns (2005).

[4] Between 2004 and 2006, net interprovincial migration to Alberta accounted for an increase of 114,000, or 3.3 %, of Alberta's population. At the peak of the oil boom in 2006, weekly flights were established between Fort McMurray in Northern Alberta at the hart of the Athabasca and St. John's Newfoundland via Toronto.

is negatively affected by the appreciation of the Canadian dollar (against the USD). They also strongly believe that the Canadian dollar is mostly driven by oil and commodity prices.[5] In the meantime, the brutal fall of the oil price and other commodity prices following the worsening of the financial crisis in the fall of 2008 have put a sudden death to the Canadian resource boom. Despite a slight depreciation of the Canadian dollar starting in the fall of 2008, the Canadian manufacturing sector was further shaken by the worsening of the US economy.

A growing academic literature also addresses related questions to the Dutch disease hypothesis. For the issue at stake here, there are two interesting and complementary strands in the literature. A first strand tests whether the CAD/USD exchange rate is driven in the long run by oil and commodity prices.[6] Basically, these analyses revisit the Amano and van Noorden (1995) exchange rate equation. With some nuances, those papers conclude that the CAD/USD has become over the recent period a currency driven up and down by the evolution of commodity and oil prices. A second strand (Coulombe et al., 2007, Acharya and Coulombe, 2008) aims at capturing the impact of fluctuations of the CAN/USD on the evolution of Canadian manufacturing output and employment. It provides strong evidence in favor of a substantial adjustment in terms of employment to the big appreciation of the Canadian dollar over the 2002-2007 period.

In this paper, we revisit the issue of a Dutch disease affecting the Canadian economy. We first argue that the evidence provided by the existing literature is insufficient to assess the importance of such a phenomenon in Canada. The main reason is the following. Basically, two conditions need to be fulfilled before ascribing the recent evolution of the Canadian manufacturing sector to a Dutch disease. First, the evolution of Canadian currency should be clearly driven by the evolution of energy and/or commodity prices. Second, that part of the appreciation associated to commodity and/or energy prices should affect negatively the Canadian employment in the manufacturing sector. By simply looking at the bilateral CAN/USD, the existing literature is unable to extract the part of the evolution affected by commodity and oil prices. By definition, an appreciation of the bilateral CAN/USD is driven by the strength of the CAD currency but also by the weakness of the USD whose evolution might be independent of those commodity prices. Our results support this conjecture. Therefore, from the observed evolution of the CAN/USD, one needs to disentangle the variation of the CAD that might be related to the variation of commodity prices from the one associated to the evolution of the USD. Even in the presence of a Dutch disease effect, a failure to disentangle both currency components will lead to a possible bias in the estimation of the magnitude of the effect. The drawback of using the traditional approach based on the use of the bilateral exchange rate is particularly serious since the recent period (2002-2008Q3) exhibits three concurrent evolutions: an appreciation of the Canadian dollar in effective terms, a sharp depreciation of the USD in effective terms and finally a strong increase in commodity

[5] See for instance the papers and transcripts of oral interventions of the Toronto conference in January 2008 entitled "Implications for Canada of a High-valued Canadian Dollar. Has the Canadian Economy Caught Dutch Disease?" The transcripts are available at www.ppforum.ca.

[6] See among others Mayer and DePratto (2008), Issa et al. (2006), Bayoumi and Mulheisen (2006), Heliwell et al. (2004).

and oil prices. By looking at the relationship between the CAN/USD and the commodity prices, the analysis implicitly assumes that those prices will affect symmetrically the two currencies. We show that this assumption is highly rejected by the data and as a result, tackling this issue requires another approach.

Will the use of effective exchange rates do the job? Effective exchange rates are very often used as indexes of the strength of a particular currency. Unfortunately, in the case of the Canadian dollar, the effective exchange rate will be almost similar to the bilateral CAN/USD as a very large part of the Canadian trade is with the US (in 2006, the US supplied 65% of the Canadian imports, and purchased 79% of Canada's merchandise exports).[7] As a result, the use of the Canadian effective exchange rate would be subject to the same previously mentioned problem. In this paper, we provide another approach that aims at solving this issue.

Using the original Bayesian approach of Bos and Shephard (2006), we extract from a set of bilateral exchange rates currency components capturing the strength of the currencies such as the CAD and the USD. Importantly, our method is fully independent on the trade weights that are usually used to define effective exchange rates. Thereafter, the US component is use to extract the effect of the USD from the energy and commodity prices. Then, it is first possible to assess whether and how much each currency component is associated to the evolution of the commodity prices. In turn, this approach allows us to quantify the part of the recent loss of the Canadian manufacturing employment associated to the recent increase of the commodity prices, accounting for the movements of the CAD and the USD that are unrelated to the evolution of those prices.

Our analysis provides simple but important figures and conclusions concerning the case for a Dutch disease in Canada. First, we show that the recent dramatic appreciation of the CAD/USD exchange rate (around 50%) might be decomposed into a 62% appreciation of the Canadian currency and a 38% depreciation of the USD currency. Second, the decomposition of the Canada-US bilateral exchange rate into a USD and a CAD component shed new light on the relationship between the Canadian exchange rate and energy and commodity prices. Third and more importantly, given the estimated respective responses of the Canadian employment to the evolution of each currency component, we find in the end that only 54% of the CAD/USD appreciation that affects Canadian employment might be ascribed to the rise in commodity prices. Finally, our approach allows to identify the manufacturing sectors that have been subject to the Dutch disease, i.e. those in which the decrease in activity might be directly related to the rise in oil and commodity prices.

This paper is organized as follows. Section 2 reports some stylized facts emphasizing the need of a new approach. Section 3 presents the econometric approach and reports the extracted currency components. Section 4 revisits the AvN equation using our new approach. Section 5 analyses the impact of the evolution of the currency components on the Canadian manufacturing employment. Section 6 concludes.

[7] The empirical analysis of Coulombe (2007) illustrates well how the 1989 Canada–United States Free Trade Agreement has exerted a significant positive long-run effect on GDP per capita.

2. Stylised facts

The case of a Dutch disease in Canada has been recently revisited due to the concurrent evolution of a set of macroeconomic and financial variables. Figures 1 to 3 depict the evolution of the key variables involved in the debate. Figure 1 displays the evolution over the last 35 years of the bilateral CAN/USD exchange rates, both in real (red line) and nominal (green line) terms. The figure plots the number of Canadian dollar per US dollar. The dramatic appreciation of the Canadian currency against the USD is easily identified for the last part of the period. Between the beginning of 2002 until the end of 2007, the Canadian dollar appreciated by about 49% against the USD.[8] A second interesting observation is that the real appreciation of the CAD against the USD comes almost exclusively from the nominal appreciation of the exchange rate. Indeed, the evolution of relative prices between Canada and the US explains virtually nothing in the real evolution of the CAD/USD exchange rate. For the analysis of the Dutch disease, this implies that we should be indifferent working with the real or the nominal exchange rate.

Figure 1: Nominal and Real CAD/USD exchange rate

Figure 2 plots the evolution in real terms of energy prices and those of the other commodities. Both indices are deflated using the US price index. The dramatic rise of oil prices and commodity prices beginning in 2002 is also highly visible from the plots. For the oil price, the level in real terms reaches an all-time high, even when compared to the level in the aftermath of the second oil shock. For the commodity prices, the recent rise appears more to be part of a catching-up process in historical terms.

[8] Actually, using daily data and taking the minimum value of the rate in 2002 and the maximum one in 2007, the maximal nominal appreciation amounts to 56%.

Figure 2: Evolution of real log-commodity prices: all commodities and energy

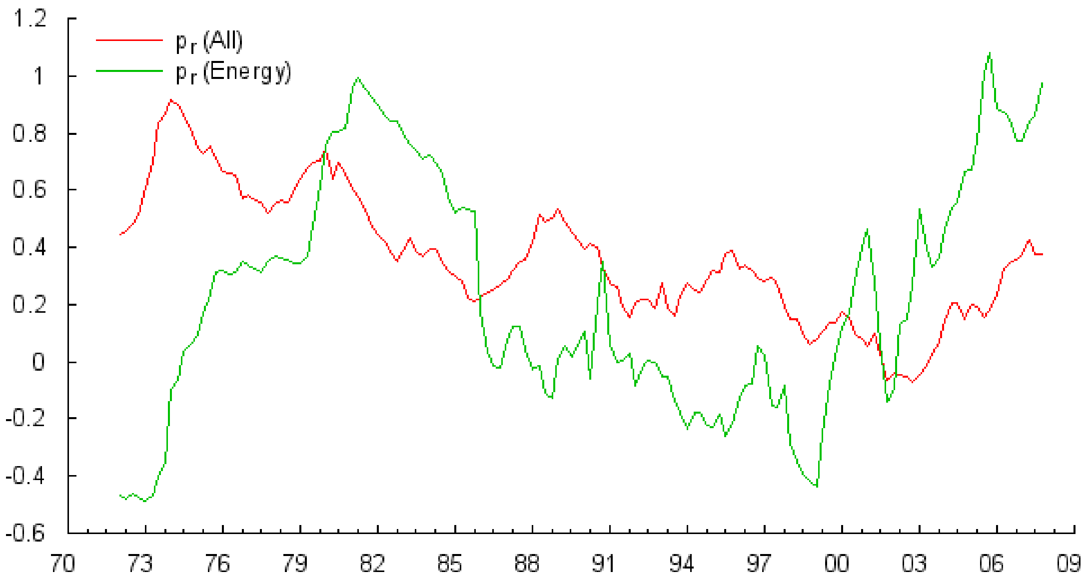


Figure 3: Share of Canadian manufacturing employment

Figure 3 reports the evolution over time of the Canadian employment in the manufacturing sector as a share of total employment. The figure makes clear that the recent decrease in the relative part of the manufacturing sector is not an exceptional event. Like other industrialized countries, due to the development of services, the share of Canadian manufacturing output tends to decrease in the long run. Nevertheless, the striking point is the relative quickness at which this share decreased after 2001. The three joint evolutions after 2001, i.e. the appreciation of the CAD/USD, the strong increase in commodity and energy prices and the quick decrease in the size of the manufacturing sector show that there is a potential case for a Dutch disease in Canada. This has led a lot of policy makers to express big concerns about the seriousness of such a phenomenon in Canada.

To what extent can we ascribe the decrease in manufacturing employment to the rise in oil prices? A first and important step is to test whether the evolution of the Canadian currency has been driven by the rise in commodity an oil prices. As mentioned above, most of the analyses have relied on the bilateral CAD/USD, either in nominal or real terms. Such an approach exhibits one important weakness. The evolution of the CAD/USD is driven not only by the evolution of the Canadian currency but also by the evolution of the US dollar which is unlikely to be driven by economic conditions in Canada. Had the USD been quite constant over the investigated period, such an analysis could do the job. The big problem is that it is far from being true, especially over the sub period of interest. Figure 4 shows the evolution of the nominal effective exchange rate of the USD over the 1979-2007 period. It is obvious that the USD has depreciated significantly over the 2002-2007 period against most of the currencies of the US trading partners, including of course the CAD. The weakness of the US currency has been widespread over this period and needs to be analysed separately from the evolution of the Canadian currency.

Will a separate analysis of the Canadian effective exchange rate and the US effective exchange rate solve this problem? Unfortunately not. The reason is that given the very high proportion of the Canadian trade with the US, the effective rate for Canada will be quite close to the bilateral CAD/USD. After 1996, the weight of the USD used in the computation of the Canadian-dollar Effective Exchange Rate Index (CERI) amounts to about 76 percent. This weight would be even more important if we were using the real proportion of the trade with the US. This share has indeed increased over the last 30 years due to the implementation of the Canadian-US Free Trade Agreement (see Beine and Coulombe, 2007). This is especially true after 1995 when the major part of the integration process has been completed. Figure 5 confirms that using the Canadian effective rate is useless. Over the last 15 years, one cannot see any significant difference between the nominal bilateral CAD/USD rate (CAD/USD, red line), the nominal effective rate (Nom Eff CAD, green line) and the real effective exchange rate (Real Eff CAD, blue line). As expected, the correlation between the 3 rates has increased over time, reflecting the high degree of integration between the Canadian and the US economies.

Figure 4: US nominal effective exchange rate

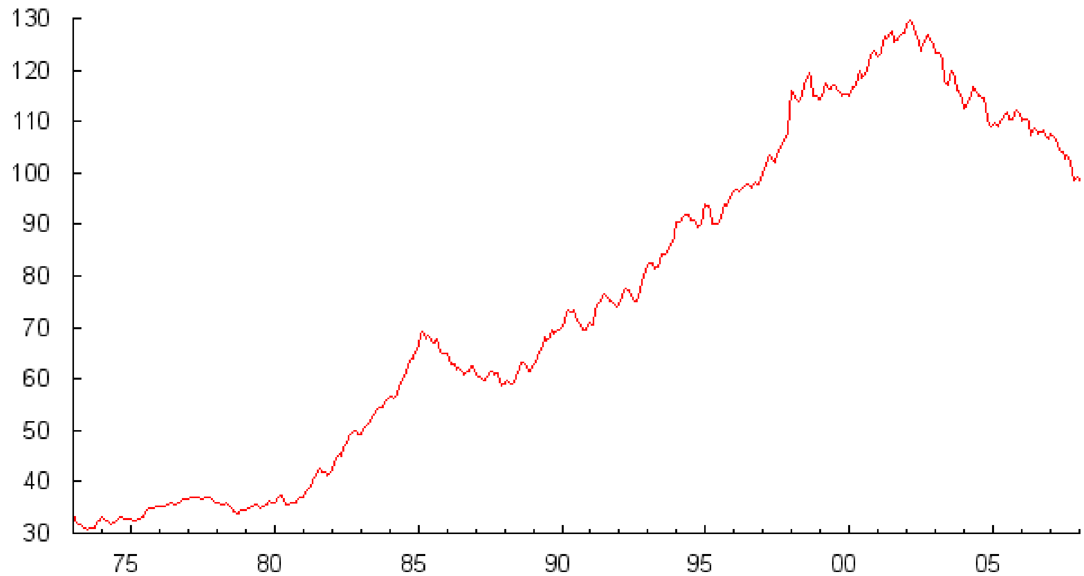
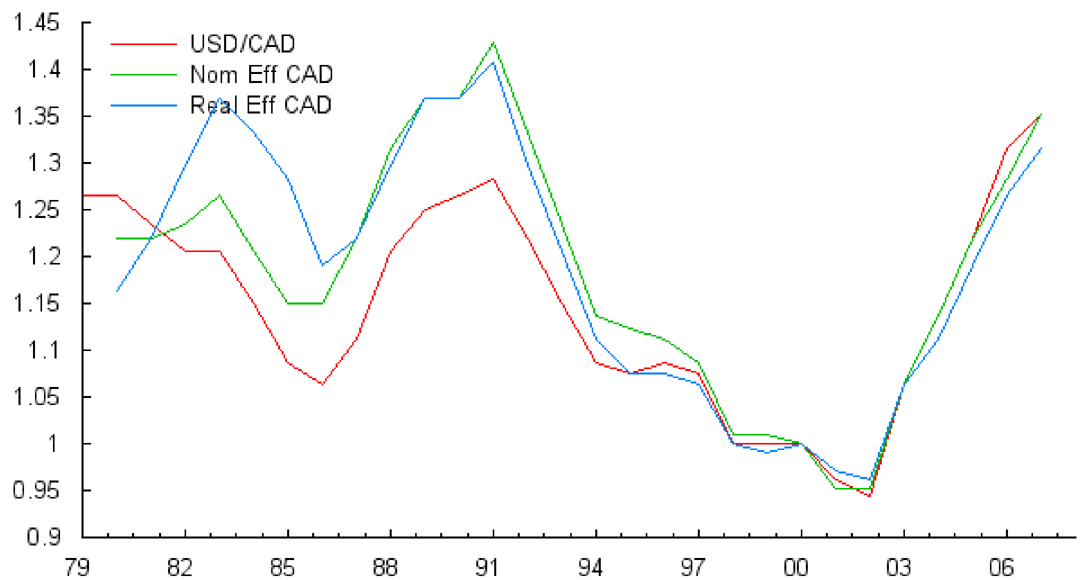


Figure 5: Evolution of CAD exchange rates : nominal CAD/USD, nominal effective CAD and Real effective exchange rate.



Using the traditional measures of exchange rates, the issue seems to lead to a non solution conundrum. Indeed, what we need is to have an index of the Canadian currency that is fully independent of the US currency. This paper offers a solution by relying on a new approach to measuring currency evolution. This approach has been initially developed by Bos and Shephard (2007) and has been successfully applied in a number of exchange rate problems like the one concerning the impact of FX central bank interventions (Beine, Bos and Laurent, 2007). For our purpose, the major advantage of this approach is that it allows to extract currency index (called hereafter currency components) that are independent from any weighting scheme such as the trade weights used in the effective exchange rates. This approach and the resulting output are presented in the next section.

3 Extracting currency components

3.1 Modelling the level and the volatility of currency components

Following Bos and Shephard (2006), who build forth on work by Mahieu and Schotman (1994), we extract the movements in levels of currencies by describing the logarithm of the exchange rates as the difference between currency factors. For a system of k exchange rates against a common denominating currency, there would be k+1 of such currency factors.

Though it is not possible to extract precisely the level of the k+1 factors out of k observations of exchange rates, the movements of the exchange rates are informative about the relative movement of the underlying factors. Take for instance a situation in which the U.S. dollar is, on a specific day, weakening 5% against both the British pound and the Japanese Yen. Then this seems to imply that the U.S. currency factor dropped 5%, with the pound and yen remaining stable. If the dollar only dropped relative to the pound, but not to the yen, then the movement is more likely to have resulted from a (relative) strengthening of the pound. To be able to quantify such movements, a formal model is described in Appendix 1. In short, the model assumes :

• a random-walk type behavior for the currency components, independent of the other currencies;

• this automatically implies a correlated system of random walks for the log-exchange rates, as often found in practice;

• the variances of the random walk increments are allowed to vary over time as well, to allow for tranquil or more hectic periods in each of the currency markets. The underlying system for the volatilities is an integrated stochastic volatility model, for each currency separately;

• the data set incorporates as well two series on the log-prices of Canadian commodities and energy, both expressed in U.S. Dollars. The model interpolates the monthly price series, and splits the prices into a pure ‘price’ component and a second component due to changes in the U.S. Dollar;

• though such a model is not ‘perfect’, as e.g. it does not model explicitly the jumps in the exchange rate when the Australian dollar is devaluated in the earlier years of the sample, it gives a sufficiently rich description of the exchange rate movements for the present purpose;

• estimation is performed using a Bayesian Markov Chain Monte Carlo MCMC) method. This results in an estimate of the posterior mean (and also spread) of the currency level and volatility factors, which can be used in a subsequent analysis of the Dutch disease in Canada.

For further details on the precise specification, and the estimation procedure, see Appendix A.

3.2 Resulting currency factors, 1971–2007

In the subsequent analysis, we use daily exchange rates of the U.S., Australian and Canadian dollars, and the Japanese Yen and British pound, over the period of 7/1/1971–10/1/2007, for a total of 9326 days. Starting in 1972, we use the price of (Canadian) commodities and energy expressed in U.S. Dollars, available at a monthly frequency at the first working day of the month.

Figure 6: Evolution of U.S. (top) and Canadian (bottom) currency level (left-hand axis) and volatility (right-hand axis) factors

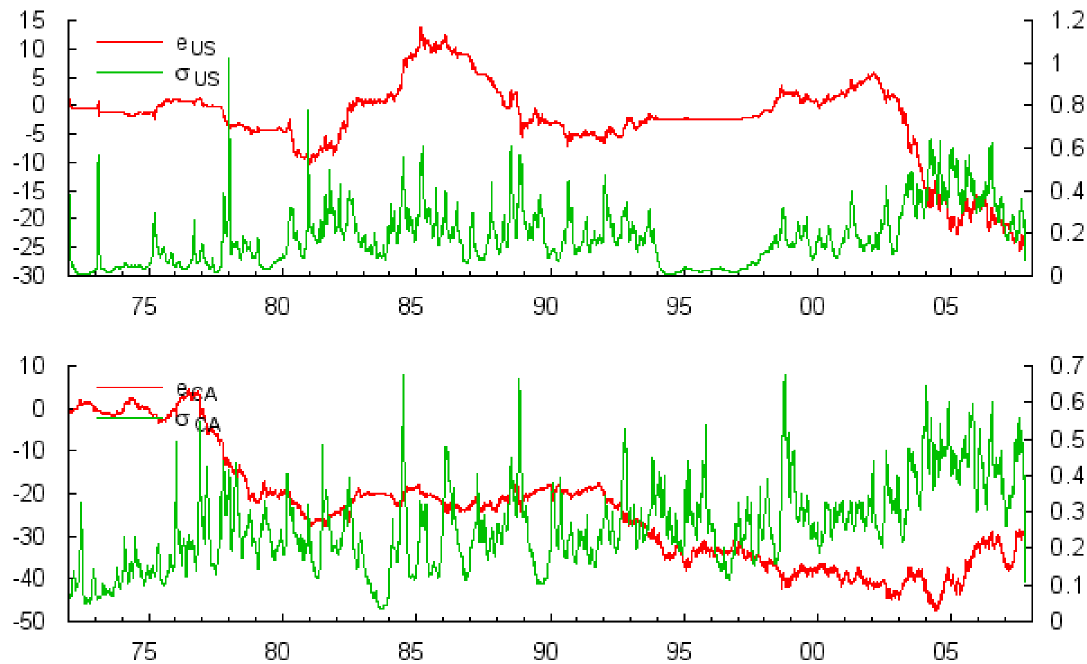
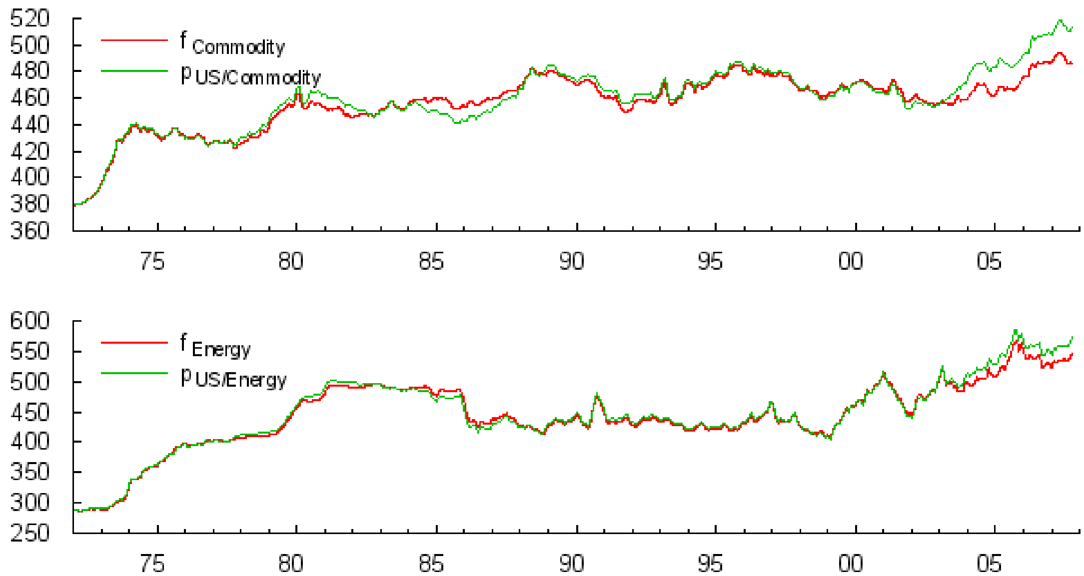


Figure 6 displays the factors for the U.S. and Canada, over the full period. For the other currencies, similar factors are extracted but not displayed here. The top panel displays the currency level factor (on the left-hand scale), together with the volatility factor (against the right-hand scale) for the United States. Initially, little movement is seen, with few variations until 1980. The level of the US component reflects the steady appreciation of the USD between 1980 and 1985, leading to the Plaza and the Louvre agreements and the subsequent depreciation of the US currency until 1991. The moments of the sharp depreciations correspond to the sudden spikes in the extracted volatility. The period of 1994–1998 was exceptionally tranquil for the dollar, with virtually no movement as also reflected by the low volatility over these years. This appears to have been a period when the other currencies seem to have evolved rather independently vis-a-vis the dollar, with few occasions where e.g. all other currencies lost ground implying a global appreciation of the dollar. Afterwards, the dollar increased in strength until 2002, followed by a steep decline of the value of the dollar against most other currencies. The last two years, this decline continues, though at a lower volatility than in the period of 2004–2006.

For Canada, there are fewer outstanding features. Uncertainty in the earliest periods was relatively low. A strong depreciation occurred throughout 1977-1979, with stability following througout the 1980s. Uncertainty for the Canadian currency over 1994–1998 was considerably higher than for the U.S.; this may partly have been caused by the fact that the Canadian dollar is not such an important currency internationally. From roughly 1990 onwards a very slow but steady decline of the value of the currency is visible. Around 2003 however, the Canadian dollar started its rise against other currencies, only broken by intermediate spells of uncertainty and temporary depreciation.

Figure 7: Evolution of the commodity (top) and energy (bottom) log-prices, together with corresponding price factors



In Figure 7 the evolution of prices is displayed. The commodity and energy prices in Canada are originally expressed in U.S. Dollars, at a monthly frequency. The state space modeling approach allows to interpolate the series to a daily frequency, and to extract from it the dollar effect. The figure displays in the top panel the log-price of Canadian commodities, which, adapted for the U.S. currency factor, delivers the commodity price factor. The difference between the price and the factor is precisely the value of the U.S. factor of the top panel of Figure 6. From Figure 7, it is seen how commodity prices did rise over the years, but in the latter years an important part of the price hike was caused by the U.S. dollar weakening in value. The final value of the commodity factor is for instance only marginally higher than its value in 1994.

The price hike of energy however was far larger in magnitude. Even after adapting for the currency effect, the resulting increase is still of around 120 points over the latter 13 years of the sample. As the prices are expressed on a logarithmic scale (multiplied by 100), this increase in the energy price since 1984 corresponds to a rise of roughly 120% over the period.

Figure 8: Evolution of the currency components : USD and CAD

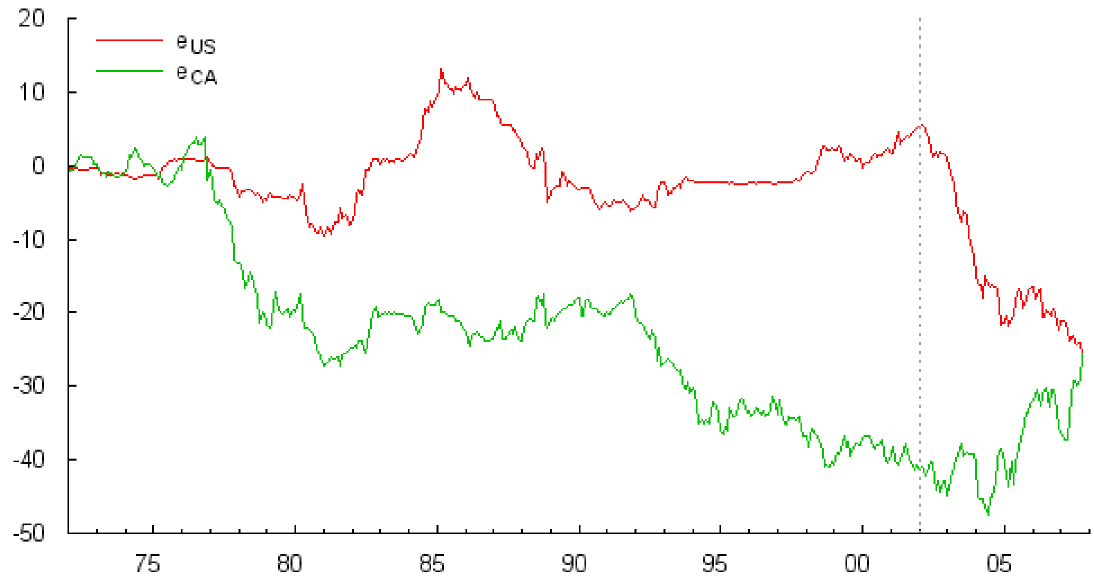


Figure 8 plots the evolution of the extracted USD and the CAD components over the full period (1972-2008). Two main comments are in order. First, our estimated components fully confirm that the sharp appreciation of the CAD/USD exchange rate is the results of two concomitant evolutions. The strong appreciation over the 2002-2007 period is indeed the outcome of a sharp strengthening of the Canadian currency but also of that of a weakening of the USD currency with respect to the other major currencies of the world. Second, our estimations allow to extract the contribution of the two components to the appreciation of the CAD/USD over this period. Actually, 62% (resp. 38%) of the 50% appreciation of the bilateral exchange rate is due to the strengthening (resp. weakening) of the CAD (resp. USD) component. Previous approaches based on the bilateral rate would end up ascribing the variations in commodity and energy prices to the total appreciation of the CAD/USD. We challenge this view and argue that this needs to be tested. While the evolution of Canada as a net exporter of primary products raises a case for the CAD to be a commodity currency over the last 25 years, there is little economic rationale to believe that the USD has been driven down by those prices. Alternative explanations, recently proposed for instance by Obstfeld and Rogoff (2007) and emphasizing the role of the US external imbalances can be considered.

4. Has the CAD become a commodity currency?

4.1 The related literature : the Amano-van Noorden equation

Most of the empirical approaches testing the determinants of the CAD/USD dollar rely more or less on the early contribution of Amano and van Noorden (1995). Basically, Amano and van Noorden (1995) (AvN hereafter) uses an error correction model of the CAD/USD real exchange rate (over the 1973 M1- 1992 M2 period) in which the long-run evolution depends on the prices of the exported energy and non energy commodities. The short-run dynamics depends furthermore on the differential Canada-US interest rate which is found to be stationary (I(0))[9]. The main findings are the following. First, there is a long-run relationship between the real exchange rate on the one hand and the energy and non energy prices on the other hand. The speed of adjustment to the long-run equilibrium is such that the equilibrium is restored after about two years. Furthermore, erogeneity tests rule out any long-run reverse causality from prices to exchange rates. The second result is a puzzle. While an increase in non energy prices tend to appreciate the CAD, a raise in energy prices is found to depreciate the loony in the long run. Finally, in line with intuition, an increase in the interest rate differential tends to appreciate the CAD.

Basically, the empirical subsequent analyses of the CAD/USD update the estimations of Amano-van Noorden (1995) and revisit the equation in different directions. Basically, their findings suggest that the long-run relationship between energy prices and the exchange rate is subject to structural break(s). Issa et al. (2006) find that the AvN equation does not provide any explanatory power over the 1973-2005 period. Heliwell et al. (2005) do not find any robust relationship between commodity prices and the CAD. From preliminary data inspection, they do not consider a role for energy prices. Maier and DePratto (2008) find some evidence of a structural break in the relationship around 2002. They document that after 2002, the relationship between energy prices and the exchange rate might have changed, from a negative to a positive impact. The related question, which is unaddressed by the authors, is why 2002 would be associated to a structural break. Bayoumi and Mülheisen (2006) provides an answer by introducing the Canadian net export position of energy goods. These net export positions are found to influence the long-run dynamics of the exchange rate and influence the way energy prices impact the rate in the short run. They suggest that the magnitude of the production and exports of the energy goods might condition the relationship between the commodity prices and the CAD/USD.

The extraction of each currency component allows us now to revisit the influence of the commodity and energy prices on the value of the CAD currency. To that aim, we follow

[9] More precisely, the interest rate variable involves the differential between the short run- long run differential between Canada and the US.

the AvN approach and assess its relevance on each of the currency components, i.e. the CAD (denoted by eca_t) and the USD (denoted by eus_t) components. For the sake of comparison, we also provide the same analysis on the bilateral real exchange rate CAD/USD. It is denoted by r_t. We consider three different periods : (i) the full period ranging from 1972Q2 (the starting period of the AvN analysis) to 2007Q4; (ii) the 1972Q2-1993Q4 period which is the period of investigation of AvN; (iii) the 1983Q1-2007Q4 period during which Canada has become a net exporter of energy goods (see Bayoumi and Mühleisen, 2006). The results reported below are obtained with quarterly data. Nevertheless, it should be emphasized that we have strikingly similar results using monthly data.[10]

The starting underlying ECM equation of our analysis is written as :

$$\Delta x_t = \gamma_1 - \gamma_e \Delta pe_t - \gamma_{ne} \Delta pne_t - \gamma_{id} idiff_{t-1} - \alpha x_{t-1} - \beta_e pe_{t-1} - \beta_{ne} pne_{t-1} + \varepsilon_t \qquad (1)$$

where x_t stands either for r_t, eca_t or eus_t. pe_t and pne_t are the real energy and non energy prices and $idiff_t$ is the differential between 3 month nominal interest rates in Canada and the US. The construction of the variables and the data sources are detailed in Appendix 2. For the sake of interpretation, we define each dependent variable such that an increase of its value corresponds to a depreciation. An increase in r_t, eca_t and eus_t therefore corresponds respectively to a real depreciation of the Canadian dollar against the USD, to a depreciation of the Canadian currency and a depreciation of the US dollar. This means that if energy prices and non energy prices should go hand in hand with the Canadian dollar in the long run, we should have positive values for β_e and β_{ne}. Equivalently, if increases in energy prices, in non energy prices and in the interest rate differential tend to appreciate the Canadian dollar in the short run, we should have positive values for γ_e and γ_{ne}, γ_{id} .

[10] These results are not reported here to save space but can be provided upon request. This is not surprising given the fact that with long-run analyses involving I(1) variables, what matters is more the time span rather than the frequency of the data (See Otero and Smith, 1999 on this).

Table 1 : Short and long-run determinants of CAN/USD real exchange rate

Parameters	Variables	1972Q2-2007Q4	1972Q2-1993Q4	1983Q1-2007Q4
γ_C	Constant	0.008	0.070***	0.021
		(0.016)	(0.017)	(0.020)
γ_e	Energy SR	0.078***	0.007	0.007
		(0.020)	(0.020)	(0.020)
γ_{ne}	Non energy SR	0.140***	0.048	0.048
		(0.041)	(0.041)	(0.041)
γ_{id}	Int diff SR	0.0016	0.007***	0.007***
		(0.0015)	(0.002)	(0.0015)
α	Speed of adj	0.021	0.176***	0.046
		(0.039)	(0.043)	(0.043)
β_e	Energy LR	0.002	-0.019***	0.020**
		(0.016)	(0.006)	(0.010)
β_{ne}	Non energy LR	0.002	0.067***	0.142**
		(0.016)	(0.017)	(0.060)
R^2		0.169	0.366	0.228
DW		1.324	1.16	1.41
Nobs		143	87	100

Tables 1, 2 and 3 present the estimation for r_t, eca_t and eus_t. Basically, Table 1 reproduces (with the closest possible definition of the data) the approach of AvN and updates the estimations. The estimations over the 1972-1993 period are fully in line with the results of AvN. They suggest a good fit to the exchange rate data and leave open the puzzle of the unintuitive sign for β_e. The results over the other sub periods turn out to be much less promising. The hypothesis of a long-run equilibrium relationship between the real exchange rate and the commodity prices is rejected, either over the full period or over the last period. The estimations suggest that the AvN equation involving the bilateral CAD/USD is quite unstable. Even over the 1983-2007 during which Canada has become a net exporter of energy products, the speed of adjustment remains insignificant. From the subsequent analysis, we argue that such a failure to find some long-run relationship is due to fact that the bilateral rate is partly driven by the USD whose evolution is independent from the dynamics of the energy and commodity prices.

Table 2 provides the same results for the USD component. For the full period and the last period, the estimations strongly reject any long-run relationship between the commodity prices and the USD component. The AvN equation explains virtually nothing of the US component, as reflected by the very low R^2. The speed of adjustment to the long-run equilibrium is not significant over those periods. For the specific 1972-1993 period, we find evidence of a long-run correlation between the USD and the energy prices. Interestingly, a rise in real energy prices is found to appreciate the USD component. This result concurs with Amano and van Noorden (1998) that show a positive long-run impact of oil prices on the US real exchange rate over the same period. This might explain why in the AvN equation applied to the bilateral rate, one finds evidence that a rise in the energy prices tended to depreciate rather than appreciate the CAD against the USD. Said differently, the unintuitive sign of the impact of the energy prices in the original AvN might be due to some correlation between the USD and the oil price.

Nevertheless, the relationship between the USD and energy prices seems specific to the Amano-van Noorden period. For the full period and the recent one, to the extent that the USD component might be explained, the investigation should look at alternative determinants than those involving the commodity prices. One alternative explanation suggested by the work of Obstfeld and Rogoff (2004) is the evolution of the US current account deficit. To test for such a relationship and given the failure of commodity prices to explain the evolution of the USD component (at least in the long run), we consider the inclusion of the US current account as a share of GDP. Preliminary tests confirm that this variable is stationary. This makes sense given the nature of this variable. Therefore we consider the following alternative specification for the USD:

$$\Delta eus_t = \gamma_1 - \gamma_e \Delta pe_t - \gamma_{ne} \Delta pne_t - \gamma_{id} idiff_{t-1} - \gamma_{usca} usca_{t-1} + \varepsilon_t \qquad (2)$$

where $usca_t$ is the US current account as a share of GDP at time *t*. Columns (6) and (7) in Table 2 report the estimates over the 1983-2007 period. In column (6), OLS estimates are reported while in column (7), we use instrumental variable estimation using $usca_{t-2}$ to prevent any endogeneity issue of the current account variable with respect to the USD currency. The estimations support the idea that the evolution of the USD is driven more by US domestic variables such as the US interest rate and the US current account. The current account is significant at the 5% level. The inclusion of the current account in the specification significantly improves its goodness of fit. Its sign is consistent with the idea that the adjustment of external imbalances might be done by a change in the USD currency. Since the current account collect imbalances with all US partners, one should expect our currency component to capture the necessary adjustment better than the CAD/USD. Given the size of the Canadian economy, the evolution of the US current account is exogenous for Canada. Therefore, one can claim that part of the depreciation of the CAD/USD is due to factors on which the Canadian economic policy has virtually no impact.

Table 2 : Short and long-run determinants of US component

Parameters	*Variables*	*1972Q2-2007Q4*	*1972Q2-1993Q4*	*1983Q1-2007Q4*	*1983Q1-2007Q4*	*1983Q1-2007Q4*
		OLS	*OLS*	*OLS*	*OLS*	*IV*
γ_C	Constant	0.118	0.806*	0.158	-0.712**	-0.683**
		(205)	(0.421)	(0.267)	(0.306)	(0.299)
γ_e	Energy SR	0.971*	0.991	0.897	0.001	0.003
		(1.060)	(0.968)	(1.211)	(0.012)	(0.013)
γ_{ne}	Non energy SR	1.297	0.037	1.011	0.018	0.016
		(2.308)	(2.709)	(3.117)	(0.031)	(0.032)
γ_{id}	Int diff SR	0.097	0.178**	0.159**	0.232***	0.224***
		(0.061)	(0.082)	(0.079)	(0.082)	(0.075)
γ_{ca}	Cur account	-	-	-	-0.853**	-0.840**
					(0.396)	(0.404)
α	Speed of adj	0.010	0.060*	0.009	-	-
		(0.023)	(0.033)	(0.043)		
β_e	Energy LR	0.200	0.747*	0.017	-	-
		(0.256)	(0.404)	(0.354)		
β_{ne}	Non energy LR	0.389	1.169	-0.865	-	-
		(0.447)	(0.713)	(0.928)		
R2		0.037	0.149	0.054	0.121	0.121
DW		1.403	1.316	1.519	1.67	1.68
Nobs		142	87	100	100	99

*Notes: Newey-West standard errors between parentheses *, ** and ***denote significance at the 10, 5 and 1% level. Columns (3-6) : OLS estimations. Column(7) : IV estimation,* usca_{t-1} *instrumented by* usca_{t-2}

Let us turn now to the evolution of the CAD. Table 3 provides the results of the AvN framework for the CAD component. The results contrast with those applied to the bilateral rate and the USD in many ways. First, over the 1972-1993 period, there is no long-run relationship between the Canadian currency and the commodity prices. The α parameter is not significant at usual levels. This contrasts with the findings of the bilateral rate and the USD component. Our findings can explain the so-called AvN puzzle, i.e. the seemingly unintuitive sign for the long-run effect of energy prices on the CAD/USD. This unintuitive sign is related to a positive correlation between the USD and the energy prices and has nothing to do with the evolution of the CAD over this period. Economically, this makes sense since over this period, Canada was not an important net exporter of oil and gaz. This contrasts with the most recent period, i.e. after 1983 (column

(5)). The estimations reported in the last column show that over the 1983-2007 period, the AvN equation explains strikingly well the evolution of the CAD component with those of the energy and non energy commodity prices. An increase in those commodity prices is found to lead to a long-run appreciation of the CAD currency. They also lead to some appreciation in the short run.

Table 3 : Short and long-run determinants of CAN component

Parameters	Variables	1972Q2-2007Q4	1972Q2-1993Q4	1983Q1-2007Q4
γ_C	Constant	1.414	2.446**	3.884***
		(1.195)	(1.132)	(1.22)
γ_e	Energy SR	0.029*	0.010	0.028*
		(0.017)	(0.017)	(0.015)
γ_{ne}	Non energy SR	0.068**	0.0001	0.088**
		(0.032)	(0.045)	(0.043)
γ_{id}	Int diff SR	0.072	0.157	0.183
		(0.010)	(0.125)	(0.120)
α	Speed of adj	0.038	0.067	0.099***
		(0.032)	(0.047)	(0.034)
β_e	Energy LR	0.008	-0.009	0.017***
		(0.005)	(0.008)	(0.005)
β_{ne}	Non energy LR	0.007	0.024**	0.043**
		(0.014)	(0.012)	(0.014)
R^2		0.104	0.067	0.252
DW		1.357	1.25	1.65
Nobs		142	87	100

Notes : Newey-West standard errors between parentheses
*, ** and ***denote significance respectively at the 10, 5 and 1% level.

Let us summarize the main findings and implications.

- First, we find that the unintuitive sign for the long-run impact of energy prices on the real CAD/USD in the original AvN equation is due to the fact that over this specific period, there is a positive correlation with the USD currency while no correlation with the CAD currency.
- In contrast, over the last period, we have exactly the opposite situation: the commodity prices affect the strength of the CAD currency while they have no effect at all on the USD. This is line with the fact that Canada has become in the meantime a net exporter of commodities.
- These findings support the case of a Dutch disease in Canada. Nevertheless, one should qualify this phenomenon of partial as only about 63% of the strong appreciation of the CAD/USD is due to the increase in commodity prices.

5. The evolution of the CAD and the Dutch disease (Serge)

5.1. Specification and estimation techniques

The effect of currency components on the Canadian manufacturing sector is estimated using an adaptation of the time-series and cross-section empirical Error Correction Model used in Acharya and Coulombe (2008). We pool annual Canadian and US data for 21 industries over the 1987-2006 period. The endogenous variable, sca_{it}, is the share of employment in Canadian manufacturing industry *i (*share of total industry employment) at time *t*. The change in sca_{it} is regressed on the lagged share of employment in US manufacturing sus_{it-1}, the lagged Canadian and US currency components, the first difference of the first three controls, on its lagged level, cross-section fixed effects γ_i. The coefficient on the first difference of the Canadian component was never significant and was dropped. The ε_{it} is an idiosyncratic error term:

$$\Delta sca_{it} = \alpha sca_{it-1} + \beta_1 sus_{it-1} + \beta_{i2} eca_{t-1} + \beta_{i3} eus_{t-1} + \beta_4 \Delta eus_t + \beta_5 \Delta sus_{it} + \gamma_i + \varepsilon_{it} \qquad (3)$$

Variable sus_{it-1}, which has both a time-series and and a cross-section dimension, is designed to control for structural changes and long-run trend that are industry specific. This variable, which is always highly significant, capture the effect of many potential controls that are time specific and industry specific. Its inclusion in the adjustment model allows to capture unobserved factors explaining the differential evolution between Canadian and US manufacturing employment. The two currency components appear to perform quite well in this role.

In the homogenous specification (Table 4), the β_{i2} and β_{i3} are constrained to be the same across the *i*'s. In contrast, the effects of the currency components are allowed to vary across industries in the heterogeneous specification (Table 5). Results from the heterogeneous specifications clearly indicate that the effect of currency components varies across industries. However, in the heterogeneous specification, the effects of the currency components are not estimated very accurately given the limited number of time series observations at hand. In the homogenous specification, the mean effects of the currency components are estimated more accurately since the slope coefficients are estimated using both the time-series and the cross-section dimensions.

Cross-section fixed effects are included in all estimation to control for some of the unobserved industry heterogeneity. Note that time dummies cannot be included since the currency components have only a time series dimension. Industry specific time trends are captured by the sus_{it-1} variable.

In the homogenous specification, results are presented for Pooled Least Squares (PLS) and for Iterated Feasible Generalized Least Squares (IFGLS) estimates. PLS results are presented with Panel Corrected Standard Errors that are robust to heteroskedasticity. This approach is recognized to provide standard errors that do not lead to overconfidence (Beck and Katz,1995).[11] IFGLS estimations account for cross-sectional heteroskedasticity and provide a slightly different picture from a quantitative point of view on the long-run elasticities.

We provide results for long-run elasticities computed from the point estimates of specification (3). For the homogenous specification, the long-run elasticity of the share of US employment is simply $-\hat{\beta}_1 / \hat{\alpha}$. For the Canadian currency components, the elasticity is: $-\hat{\beta}_2 / mitsca \bullet \hat{\alpha}$ where $mitsca$ is the mean across both *t* and *i* of the manufacturing industry share of Canadian employment. The US currency component elasticity is measured accordingly with $\hat{\beta}_3$ instead of $\hat{\beta}_2$. For the heterogeneous specification, the long-run elasticities of the Canadian currency components for industry *i* are computed as: $-\hat{\beta}_{i2} / m_t sca \bullet \hat{\alpha}$ where $mt_i sca$ stands for the mean share across time of industry *i*. The US currency component elasticities are measured accordingly with $\hat{\beta}_{i3}$ instead of $\hat{\beta}_{i2}$ .In Tables 4 and 5, elasticities are reported in absolute values.

All point estimates form the homogeneous specifications reported in Table 4 display the intuitive signs and are highly significant. The long-run elasticity of the share of US employment is well lower than 1, ranging between 0.5 and 0.65. These indicate that the industry shares of Canadian manufacturing do not move one for one with the US shares.

[11] The potential drawback of both PLS and IFGLS is that the point estimate of the lagged dependant variable in equation (3) can be biased (Nickell, 1995). Non-reported results using Kiviet-corrected estimations provide however very similar results. Refer to Acharya and Coulombe (2008) for Kiviet-corrected estimations. GMM estimations are inefficient with such a small number of cross sections.

Table 4: Effect of currency components on Canadian industry employment: homogeneous specification

Parameters	*Variables*	*PLS*	*IFGLS*
α	Lagged share of employment	-0.1548*** (0.0322)	-0.1629*** (0.0289)
β_1	Share of US employment	0.0939*** (0.0302)	0.0859*** (0.0257)
	LR elasticity	0.60	0.53
β_2	CA currency comp. LR	-0.0019*** (0.0005)	-0.0013*** (0.0004)
	LR elasticity	1.6	1.1
β_3	US currency comp. LR	0.0024*** (0.005)	0.0017*** (0.0004)
	LR elasticity	2.1	1.4
β_4		0.0014** (0.0007)	0.000093* (0.00004)
β_5		0.6148*** (0.1349)	0.5617*** (0.1208)
R2		0.20	0.17
DW		2.22	2.21
Nobs		399	399

Notes: Sample, 1987-2006 with 21 industries. Panel corrected (cross-section weights) standard error for PLS estimations between parentheses, *, **, and ***denote significance respectively at the 10, 5 and 1% level.

Interestingly, an appreciation of the Canadian currency component and a depreciation of the US currency components translate into a decrease in Canadian manufacturing employment shares. The point estimate of the US component is larger (in absolute value) than for the Canadian component but the difference between the two is not significant.

The long-run elasticities of the two currency components estimated from PLS are 1.6 and 2.1 for the Canadian and the US respectively. These numbers are smaller from IFGLS estimations (1.1 and 1.4 respectively) suggesting that the point estimates of currency components from PLS might be driven-up by the presence of outliers.

Table 5: Effect of currency components on Canadian industry employment: heterogeneous specification

Industry	CA currency comp.	LR elasticity	US currency comp.	LR elasticity
Food Manufacturing	-0.0014	-	0.0023	-
Beverage and Tobacco	0.0009	-	0.0017**	1.8
Textile Mills	-0.0032***	6.9	-0.0003	-
Textile Product	0.0014	-	0.0008	-
Clothing Manuf.	-0.0024	-	0.0053**	2.0
Leather & Allied Prod.	-0.0002	-	0.0003	-
Wood Product	-0.0044***	1.2	0.0054***	1.5
Paper	0.0041***	1.3	0.0025	-
Printing	-0.0029**	1.3	0.0038**	1.6
Petroleum and Coal	-0.0006	-	0.0001	-
Chemical	-0.0023	-	0.0025	-
Plastics and Rubber	-0.0058***	2.1	0.0024	-
Non-Metallic Mineral	-0.0009	-	-0.0002	-
Primary Metal	0.0026	-	0.0035*	1.3
Fabricated Metal	-0.0071***	2.0	-0.0009	-
Machinery	-0.0089***	3.3	0.0031**	1.2
Computer and Electro.	-0.0079**	3.0	0.0000	-
Electrical Equipment	-0.0008	-	0.0006	-
Transportation Equip.	-0.0088***	1.3	0.0056**	0.85
Furniture	-0.0047**	2.0	0.0035**	1.8
Miscellaneous	-0.0026*	1.2	0.0012	-
α	-0.3349***			
R2	0.28			
DW	2.32			
TSCS obs	399			
Cross-section obs	21			

Notes : Sample 1987-2006 with 21 industries. The effect of other controls in specification (3) not displayed. White cross-section standard errors between parentheses. *, **, and ***denote significance respectively at the 10, 5 and 1% level. The insignificant LR elasticties are not displayed

Point estimates of the currency components that vary across industries are displayed in Table 5. The speed of adjustment α is also reported and the point estimate (0.335) is around two times larger than in the homogenous specification. This implies that the industries appear to adjust more rapidly when they are allowed to react differently from exchange rate changes.

Despite the lack of accuracy intrinsic to the estimation of the industry-specific slope coefficient with just 21 cross sections at hand, 19 currency effects (out of 42) are significant at least at the 10 % level and only one has the counterintuitive sign.

From the point of view of the long-run elasticities, the three industries that are the most affected by the Dutch disease are: textile mills, machinery, and computer and electronics with elasticities ranging between 3 and 6.9. Plastics and rubber, fabricated metal, and furniture are industries that are also more affected than the average by the Dutch disease with elasticities around 2. The manufacturing industries: paper, printing, transportation equipment, and miscellaneous, are also affected negatively and significantly by the Dutch disease. All the affected industries, with the exception of printing, are highly exposed to international trade.[12] There is no systematic pattern between the degree of technology intensity (following the OECD classification for low- medium- and high-tech industries) and the degree of exposure to the Dutch disease.

The elasticities for the long-run effect of the US currency component for the eight industries for which the effect is significant vary between 0.85 and 2. With the exception of beverage and tobacco, printing, and primary metal, the other industries affected by the US component are highly exposed to international trade. Again no relationship is observed between the degree of technology intensity and the exposure to the US component. The industries that are affected by the two currency components with the intuitive signs are: printing, machinery, transportation equipment, and furniture. The industries that are only affected by the US currency components are: beverage and tobacco, clothing manufacturing, and primary metal. The industries that are affected only by the Canadian currency components are: textile mills, computer and electronics, plastics and rubber, fabricated metal, and paper.

Industries that are not affected by both currency components are: food manufacturing, textile product, leather & allied product, petroleum and coal, chemical, non-metallic mineral and electrical equipment.

Finally, the point estimates reported in Table 4 coupled with the respective appreciation of the Canadian component and the depreciation of the US component observed between 2002 and 2008, can be used to provide the comparative contribution of these two factors to the exchange rate effect on Canadian manufacturing employment over the recent period. What comes out of the exercise is that around 54% of the decline in employment related to exchange rate developments comes from the appreciation of the Canadian component and the remaining 46% from the depreciation of the US component. This result is driven by the fact that, over the period, the change in the Canadian component was much larger than the change in the US component.

Conclusion

In this paper, we have investigated to which extent the Canadian economy has been subject to the Dutch disease phenomenon. We argue that the use of the bilateral CAN/USD exchange rate is likely to mislead the analysis the Dutch disease in the case of the Canadian economy. The reason is that the evolution of the CAN/USD exchange rate might be driven by factors that affect only the USD. The use of the effective exchange rate of the Canadian dollar is of little help to solve this issue since it is highly correlated with the CAN/USD bilateral exchange. In this paper, we propose a new solution that allows to disentangle exchange rates into currency components capturing the strength of the respective currencies. Importantly, the decomposition is independent of the trade weights usually used to define effective exchange rates.

[12] We follow here and thereafter the taxonomy established by Dion (1999) to classify the industries according to their degree of trade exposure.

Our results challenge the conclusion of the Amano-van Noorden (1995) exchange rate equation linking the evolution of the CAD/USD to the price of oil and natural resources. They also bring new insights about the determinants of the CAD. First, we show that the counterintuitive sign of the oil price in the CAD/USD exchange rate of Amano and van Noorden (1995) is exclusively due to a positive correlation of the USD with the oil price over this particular period (1972-1992). Second, we show that over the recent period during which Canada has been a net exporter of oil and primary products (1983 onwards), the Canadian currency has been driven up by the prices of commodities. In contrast, the evolution of the USD seems disconnected from that of the prices of oil and primary products but driven rather by US specific factors such as the evolution of the US current account deficit.

Using our decomposition, we show that the appreciation of the CAD explains about two-thirds of the sharp appreciation of the CAD/USD over the 2002-2008 period. The sharp depreciation of the USD over the same period explains the rest of the appreciation of the CAD/USD. In turn, both evolutions are responsible for the losses in the Canadian manufacturing sector, with roughly similar quantitative effects but with some differences at the industry level. All in all, this allows to asses to which extent in the recent period, the Canadian economy has been subject to the Dutch disease. Nevertheless, it is also clearly show that the depreciation of the USD worsened the situation.

The substantial appreciation of the CAN/USD between 2002 and mid-2008 has been followed by a sharp depreciation of about 20 percent in the last quarter of 2008. Over the same period, the price of oil and the other commodities got back to very low levels.[13] The recent developments illustrate well why the Dutch disease should be taken into account to understanding the evolution of the Canadian economic structure and the future of its well being. As pointed out at the beginning of this paper, the Dutch phenomenon becomes a disease if the manufacturing sector does not come back when the resource boom is over. Had the Alberta's resource boom lasted for 100 years, the appreciation of the Canadian currency and the shrinking of its manufacturing sector might have been viewed as an optimal market adjustment with limited role for government intervention. In contrast, id the Alberta's resource boom is already part of history, the Dutch phenomenon may have already become a disease that challenges economic policy. We believe our paper might be of some help for understanding the recent evolution and future challenges of the Canadian economy.

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Appendix 1: Econometrics of component analysis

The input for the analysis of components is a vector $s_t = (s_{1t}, \cdots, s_{kt})'$ of *k* log-exchange rates $s_{it} = 100 \log S_{it}$ against a common currency. The common currency will be indicated by index 0. Each of the log-exchange rates is written as the difference between the currency factor of country i, e_{it} and the common currency factor, e_{0t}, as in

$$s_{it} = \begin{pmatrix} e_{1t} \\ \vdots \\ e_{kt} \end{pmatrix} - e_{0t} = e_{1-kt} - e_{0t}$$

The vector of data is enlarged with a vector of log-prices of Canadian commodities and energy, expressed in U.S. Dollars. If the U.S. is the common currency 0 used above, the full observation equation can be written as

$$y_t = \begin{pmatrix} s_t \\ p_t \end{pmatrix} = \begin{pmatrix} e_{1-kt} \\ f_t \end{pmatrix} - e_{0t}$$

where p_t are the log-prices, and f_t are the corresponding price factors. Notice that observations on the log-prices is only available once per month; for the other days, the observations of p_t are missing.

Instead of modeling the log-exchange rates and prices directly, an independent random walk structure for the factors is proposed,

$$e_{t+1} = e_t + \eta_t, \quad \eta_t \sim N(0, diag(\sigma_{et}^2))$$

$$f_{t+1} = f_t + \varsigma_t, \quad \varsigma_t \sim N(0, diag(\sigma_f^2))$$

with diag(σ_{et}^2) a *k+1 x k+1* diagonal matrix with elements σ_{et}^2 on the diagonal. The price factors f_t have fixed variances with values in the vector σ_{ft}^2. As there are only few observations on the prices available and stochastic volatility would not be estimable, these variance are chosen to be fixed over time. Finally, the disturbances η_t and ς_t are assumed to be independent; again, a dependence structure between these disturbances is not estimable from the data.

As volatilities clearly move to different levels over a sample as long as the one used in the present application, a non-stationary random walk specification for the log-variance is implemented. This integrated stochastic volatility model is specified as

$$\log \sigma_{et+1}^2 = \log \sigma_{et}^2 + \xi_t, \quad \xi_t \sim N(0, \sigma_\xi^2)$$

Essentially, all log-variances can change over time independently of what happens in the rest of the model; the variances of the individual increments are $\sigma_{i\xi}^2$.

For identification, the common currency factor is initialized at $e_{01} = 0$, leaving the other factors to start at the value of the log-exchange rate. The initial value of the variances σ_{et}^2 is estimated along with the vector of parameters $\vartheta = (\sigma_\xi', \sigma_f')'$. Estimation of the resulting non-linear state space model (Harvey 1989) is performed using a Markov chain Monte Carlo approach, see also Jacquier et al. (1994). A straightforward MCMC algorithm with data augmentation delivers good convergence properties for the model at hand.

Notice that for estimation of the parameters ϑ alternative methods like simulated maximum likelihood or GMM-based methods could be used. These alternative methods however are not as apt as the Bayesian simulation approach for extracting the posterior mean of the currency and volatility factors.

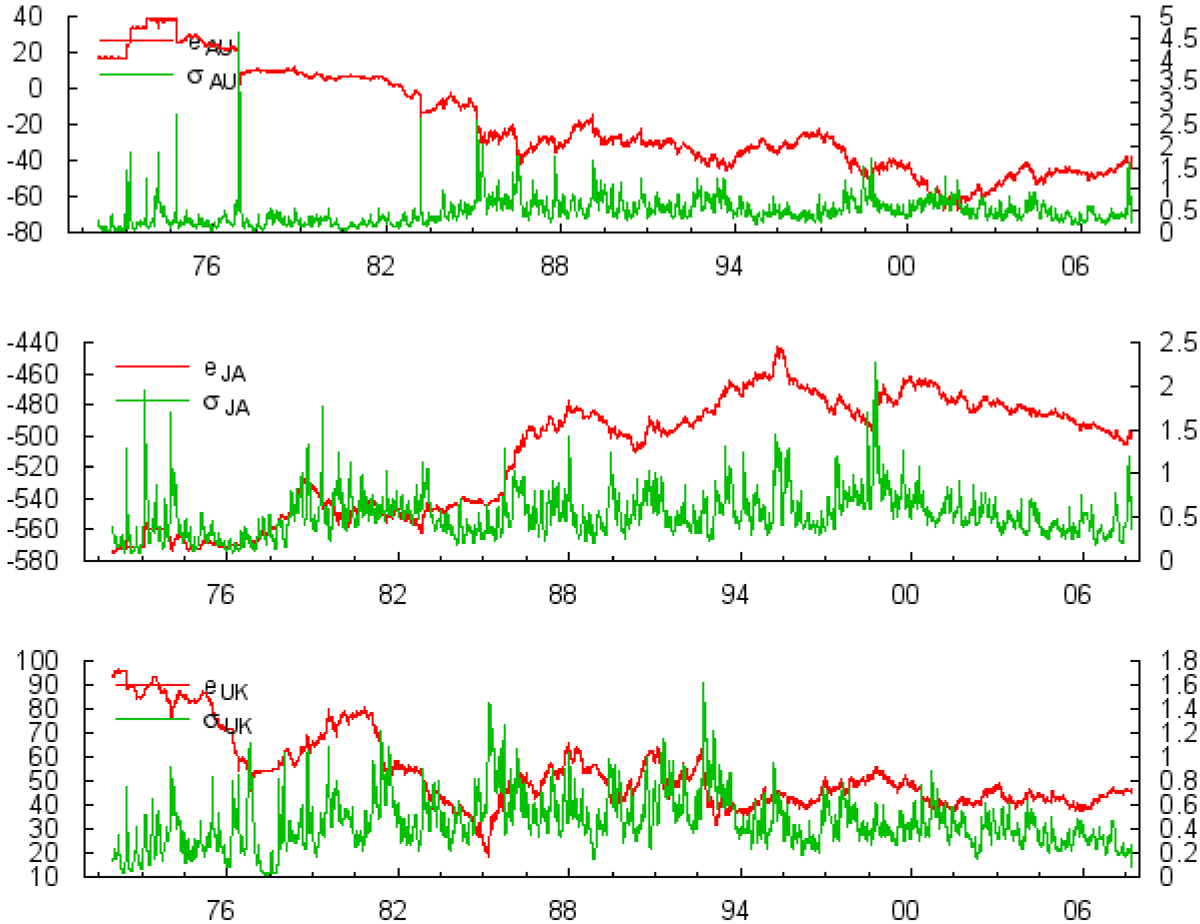
Table 1: Prior and posterior for model parameters

	Prior		Posterior			
	Mean	St. dev	Mode	Mean	St. dev	95% HPD
σ_ξ (U.S.)	0.504	(0.20)	0.293	0.293	(0.01)	[0.266, 0.321]
σ_ξ (Australia)	0.504	(0.20)	0.375	0.379	(0.01)	[0.354, 0.409]
σ_ξ (Canada)	0.504	(0.20)	0.195	0.196	(0.01)	[0.175, 0.219]
σ_ξ (Japan)	0.504	(0.20)	0.298	0.297	(0.01)	[0.270, 0.324]
σ_ξ (UK)	0.504	(0.20)	0.308	0.306	(0.01)	[0.281, 0.332]
σ_f (Commodity)	1.059	(0.55)	0.503	0.503	(0.02)	[0.468, 0.539]
σ_f (Energy)	1.059	(0.55)	1.236	1.235	(0.04)	[1.155, 1.321]

The final results are collected by sampling first a burn-in sample of 1,000 iterations, followed by a posterior sample of 10,000 iterations. The sample is not very large, as it was found that especially the objects of interest, the currency factors, converged very rapidly, and a larger sample was not necessary for measuring these. Table 1 displays the moments of the IG-1 prior densities for the parameters, and the mode, mean, standard deviation and 95% highest posterior density regions. Note that the prior densities were chosen based on previous experience, purposely taking priors with relatively large standard deviations, to allow the data to decide on the final location of the posterior density.

Figure A1 reports the evolution of the level and the volatility of the components of the other currencies involved in the estimation, i.e. the Australian dollar, the Japanese Yen and the British Pound over the 2000-2006 period.

Figure A1 : Currency components (levels and volatility) of the other currencies


e AU
σ AU
40
20
0
-20
-40
-60
-80
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
76
82
88
94
00
06
e JA
σ JA
-440
-460
-480
-500
-520
-540
-560
-580
2.5
2
1.5
1
0.5
0
76
82
88
94
00
06
e UK
σ UK
100
90
80
70
60
50
40
30
20
10
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
76
82
88
94
00
06

Appendix 2. Data sources and variable definitions.

- S_t : vector of daily exchange rates against the USD (number of USD for one unit of domestic currency): Canadian dollar (CAD), British pound (UKP), Japanese Yen (JPY), Euro (EUR); Australian Dollar (AUS); source : Datastream.
- E_t : Canadian nominal effective exchange rate, trade-weighted (code: V37426), source: Statistics Canada CANSIM II.
- P_t : Bivariate vector of monthly commodity price indexes ;

-Total commodity price index excluding energy in USD terms (1980=100); code V36383; source: Statistics Canada CANSIM II.
-Energy price index in USD terms (1980=100); code V36383; source: Statistics Canada CANSIM II.

- $r_t = \ln(\frac{1}{S_t} * \frac{q_{us,t}}{q_{ca,t}})$: log of the real CAD/USD exchange rate where $q_{us,t}$ is the US GDP deflator (2000=100), computed by the ratio of gross domestic product current dollars (code V121951) and gross domestic product chained 2000 dollars (code v21581591); source: Statistics Canada CANSIM II.

$q_{ca,t}$ is the monthly Canadian GDP deflator (2000=100), implicit price index (2002=100) (code V1997756); source: Statistics Canada CANSIM II.

- $idiff_t$: 3 months interest rate differential between Canada and the US, monthly frequency; computed as $idiff_t = ican_t - ius_t$ where $ican_t$ is the 3 month prime corporate paper rate (code: V122491) and ius_t is the US 3 month commercial paper rate adjusted (code : V122141); source: Statistics Canada CANSIM II.
- sca_{it} : share of employment of industry *i* in total manufacturing employment in Canada at time t (annual frequency); source : Labor force survey, Statistics Canada.
- sus_{it} : share of employment of industry *i* in total manufacturing employment in the US at time t (annual frequency); source : US Labor Force survey, US Bureau of Labor Statistics.
- Net interprovincial migration (footnote 2) (code v391142); source: Statistics Canada CANSIM II.