2005

The Australian Dollar's Long-term Fluctuations and Trend: The Commodity Prices-cum-Economic Cycles Hypothesis

E. Sanidas
University of Wollongong, elias_sanidas@uow.edu.au

Publication Details

Sanidas, E, The Australian Dollar's Long-term Fluctuations and Trend: The Commodity Prices-cum-Economic Cycles Hypothesis, Working Paper 05-29, Department of Economics, University of Wollongong, 2005.

University of Wollongong
Economics Working Paper Series
2005

http://www.uow.edu.au/commerce/econ/wpapers.html

The Australian Dollar's Long-term Fluctuations and Trend: The Commodity Prices-cum-Economic Cycles Hypothesis

Elias Sanidas

WP 05-29

December 2005

The Australian Dollar’s Long-term Fluctuations and Trend: The Commodity Prices-cum-Economic Cycles Hypothesis

Elias Sanidas
University of Wollongong
Wollongong, 2527
Australia
Email: esanidas@uow.edu.au
Telephone: 61-2-4221-5351

Abstract

The Australian dollar’s exchange rate (mainly in relation to the American dollar) has received a considerable attention in research and several models have been proposed to explain its trend and fluctuations. Thus, as a conclusion of this research we can say that this commodity currency very much depends on the terms of trade which in turn depend on commodity prices. The present paper is based on this conclusion and hence proposes the possibility that the Australian dollar’s behavior is overwhelmingly explained by a handful of cycles of mainly harmonic frequencies. Using the principles of Fourier analysis, a simple regression provides considerable evidence about the existence of these cycles. In addition, and as important, a search into the commodity realm demonstrates that these cycles are for example related to various cycles of mining and producing minerals. If the proposition of the present paper is true, we have a very simple yet substantial explanation of the long term trend and fluctuations of the Australian dollar exchange rate and probably of exchange rates of many other commodity currencies.

Key words: Australian dollar, Fourier, cycles, minerals.

1. Background

There are many factors as mentioned by many researchers that affect or could affect exchange rates in general. De Grauwe and Grimaldi [10] have pertinently summarized some of the main issues and explained why the fundamentals of exchange rates do not seem to work properly. Overall, there is some sort of puzzle in the determination of these rates. For example there is the puzzle of excess volatility according to which the volatility of the exchange rate by far exceeds the volatility of the underlying economic variables. Also, although the purchasing power parity (PPP) hypothesis was strongly suggested as explaining the behavior of exchange rates, recent research dismisses this hypothesis as being true at least for the Australian dollar [14]; or at least it qualifies it: “our estimate of the longrun elasticity of the exchange rate with respect to commodity prices is 0.939 and statistically not different from unity, which strongly supports the commodity-currency hypothesis” [13 p. 83].

However, these latter authors also remark: “although we fail to reject PPP and UIP[1], so long as commodity prices are included in the cointegrating relations, note that the PPP relation is inherently difficult to capture in a study of this type, for domestic price developments will not be uninfluenced by substantial shifts in domestic monetary and fiscal policies, and these are not explicitly accounted for in our model” [13, p. 96). Masih and Masih [20] have produced some interesting results that probably support our own results indirectly. They showed that the PPP hypothesis is still valid for the Australian dollar because they used fractional cointegration[2], and hence low frequency dynamics.

Thus, the Australian dollar is one of these commodity currencies (see for example [8]) that are heavily influenced by commodity prices. Usually these currencies are those of small economically defined countries (hence not being able to influence the world economy and to a considerable extent commodity prices). Consequently “the A$ appreciates (depreciates) in both nominal and real terms when the prices of certain commodities exported by Australia, e.g. coal, metals, and other primary industrial materials, rise (fall) in international markets’ [13, p. 82].

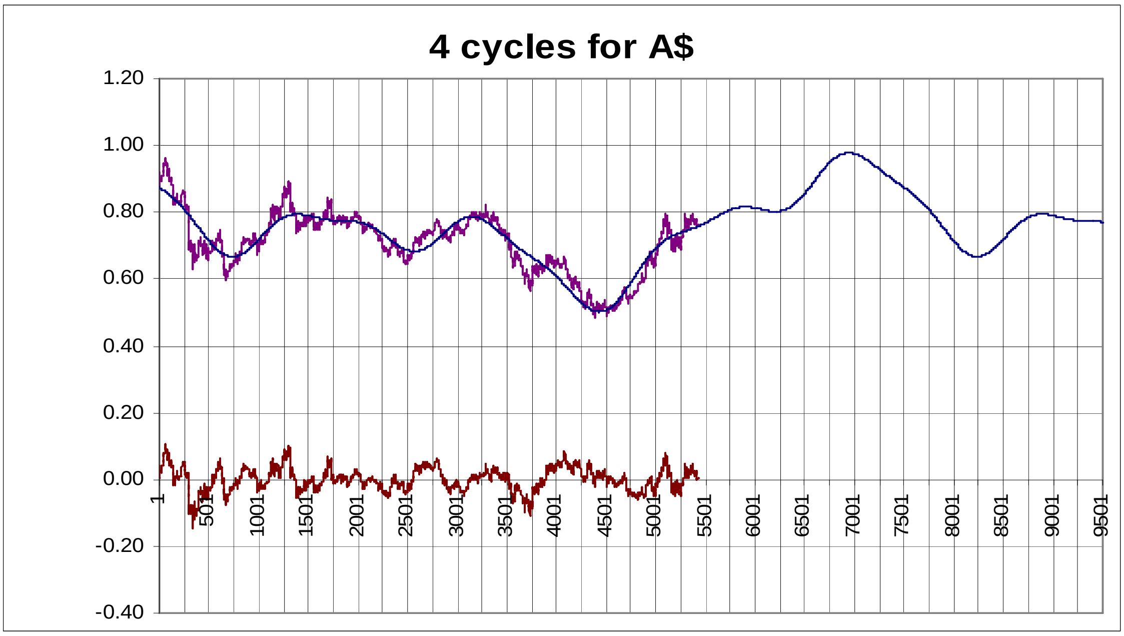
[1] UIP stands for uncovered interest parity.

[2] However, as these authors admit, cointegration is only a necessary condition for long-run PPP but not a sufficient one.

2. Commodity prices cycle and economic cycles

Following this brief background, it is logical to further investigate the relationship between the exchange rate fluctuations and the commodity prices fluctuations[3]. In this paper we will take an indirect approach: we must first see what sort of fluctuations and trends exist in determining commodity prices. Then we must investigate some of the reasons for these fluctuations and trends. Perhaps there are some hidden cycles inside the fluctuations term of commodity prices. If our suspicions are correct then we can examine the Australian dollar series to see whether these cycles constitute a very important component of its long term fluctuations. The quantitative method to be used for this examination is the Fourier analysis of time series.

Figure 1 Upper diagram: raw data and fitted line; lower diagram: residuals of the fitted model.

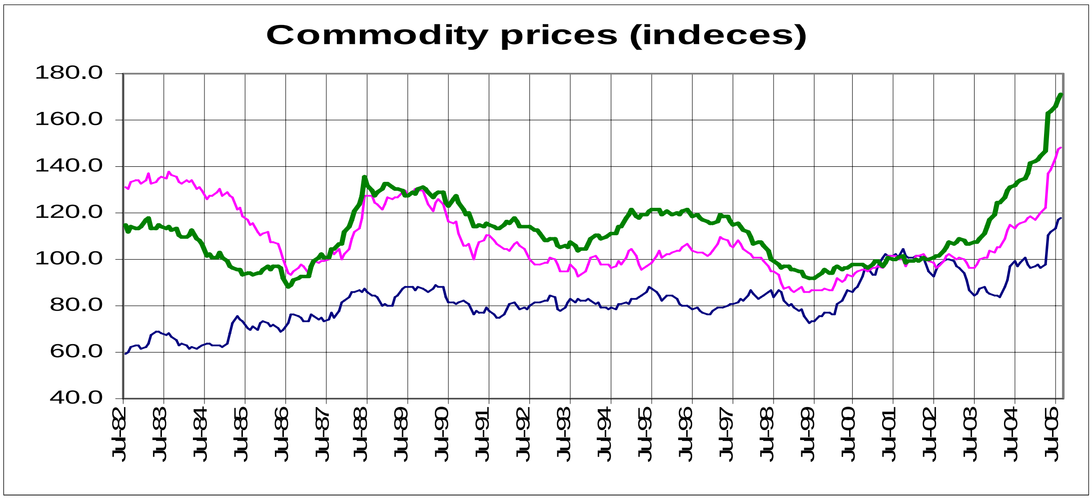


Source: graph constructed by the author, based on data of RBA official internet site [25]. The A$ is expressed in terms of US$. Note: for the fitted line and residuals see text further below.

[3] When we refer to commodity prices we mean rural and mineral commodities primarily. However, industrial commodity prices should not and cannot be absent in a more comprehensive analysis. This is even more pertinent if we remark that recently in the last 40 years or so the peaks (in 1955, 1965, 1973, 1979, 1988, and 1995) and troughs of industrial commodity prices seem to coincide with the prices of all other commodity prices [5].

A visual examination of the commodity price and exchange rate series[4] (see Figures 1 and 2) show that there seem to be some noticeable peaks and troughs approximately during the same years for both series. Cashin *et al* [4] have shown that the Australian currency (as well as 18 other currencies) is clearly cointegrated with commodity prices and that the PPP model is subsequently a weak model for countries like Australia[5]. Karfakis and Phipps [16, p. 272] have similarly concluded that "movements in the terms of trade account for much of the long-run variation in the exchange rate" of the Australian dollar (thus having already considered changes in relative price levels and interest rate differentials).

Figure 2 Commodity prices



Source of data: RBA internet site [25]. Note: the upper graph is in terms of US dollars, the middle graph in terms of SDRs and the lower graph in terms of Australian dollars.

If our hypothesis of some predetermined cycles is correct then we must search for the reasons of this predetermination. Here in this paper we suggest that these reasons are related to the mining and production cycles of minerals and perhaps other commodities that Australia exports (such as sugar and wool). An indication of how important is the Australian component of minerals in the world production we can cite Humphreys [15, p. 5]: "Australia has managed to increase its share of world iron ore production to 20% from 13%, its share of nickel mine production to 17% from 8%, its share of copper mine production to 7% from 4%, and its share of zinc mine

[4] The Australian dollar started floating in December 12, 1983. Before that from November 1976 to December 1983 it was set in terms of the trade weighted index (TWI) under a crawling peg system. Up to November 1971 it was fixed to sterling, then to the US dollar up to September 1974, and then to the TWI (see [23].

[5] These authors examine the two series in real terms.

production to 17% from 13%". Overall, exports of rural and non-rural commodities as a percentage of total exports has been about 60% (RBA site). The main commodities having the largest percentage in the construction of the commodity price index in Australia are: gold (16.3%), coking coal (13.8%), beef and veal (9.4%), steaming coal (9.3%), iron ore (9.3%), wool (8.6%), aluminium (8.6%), and so on [24].

A report by Western Mining Corporation (WMC) [26, p.31] finds that the average delay between discovery and time startup for Australian (also for Canadian and American) gold firms is 5.4 years, whereas it is 8.3 years for other countries. For copper, Graedel *et al* [12, p. 17] report all the principal uses of copper as percentage of total and the corresponding residence time in each use. Hence the weighted average of this time is about 35 years (author's calculations). Cortazar and Casassus [9] have shown that the optimal timing of a mine expansion is intrinsically related to changes in copper prices via the investment process. Achireko and Ansong [1] have demonstrated that gold prices are required in mine valuations. The relationship between supply and demand as well as inventories in mineral production has been well evidenced (e.g. [17]).

Following the above discussion we can hypothesize that the cycles we need to consider are those of commodity prices *per se* (average period length about 7-8 years) and those of economic business cycles: an average period length of about 3-4, 15-16 and 30-32 years. Cashin *et al* [6, pp. 282-3] have found that most commodities have cycles of an average duration of between 6 and 8 years. In addition, it is important to stress that most commodities are cointegrated thus generating a common cycle for themselves [21, 22]. The so-called business cycle of duration 3-4 years is primarily related to production, inventories, and employment. The "Kuznets" cycles of about 15-16 years and 29-30 years are more linked with the investment process (cf. for example a good paper on all these cycles by Forrester, [11]). In our context these three economic cycles are intrinsically related with the commodity prices cycle of about 7-8 years, since also these prices are a consequence of or a reason for the existence of these economic cycles[6]. All four cycles are generating each other through the "mysterious" properties of harmonics[7].

As we can see in figure 3 the 4 harmonics (see below for these results) produce consecutive waves with varying height (amplitude) and phase. The sequence from 1988 to 2013 of these waves is as follows (in parenthesis is the corresponding period of the cycle): 9/88 (3.75); 1/90 (7.5); 6/92 (3.75); 11/94 (15); 2/96 (3.75); 6/97 (7.5); 10/99 (3.75); 7/03 (3.75); 11/04 (7.5); 5/07 (3.75); 11/09 (15); 2/11 (3.75); 5/12 (7.5); 6/13 (30). This succession of waves of various strength and length is the reason for 85% of fluctuations in the floating exchange rate of Australian dollar (as quantitatively determined below). It is also interesting to note that in 2001 all cycles were found to be at their respective troughs and hence we had a substantial depreciation of the currency.

In addition it is important to stress that our model predicts quite accurately the peaks of economic cycles as analyzed by other scholars. For example, Bajada [2] suggested that significant peaks took place in 1989/90[8] and 1994/95; these dates coincide with our peaks of the 7.5 year and 15 year waves (see above). Finally, it might be possible to construct a new theory as the mechanics of the links between all four harmonic cycles: thus, 2 consecutive peaks of the 3.75 year business cycle in 11/84 and 9/88 generated the commodity prices cycle (of 7.5 years period) peak of 1/90; the latter in conjunction with another business cycle peak in 6/92 generated the longer investment-caused cycle (of 15 years period) peak in 11/94, and so on.

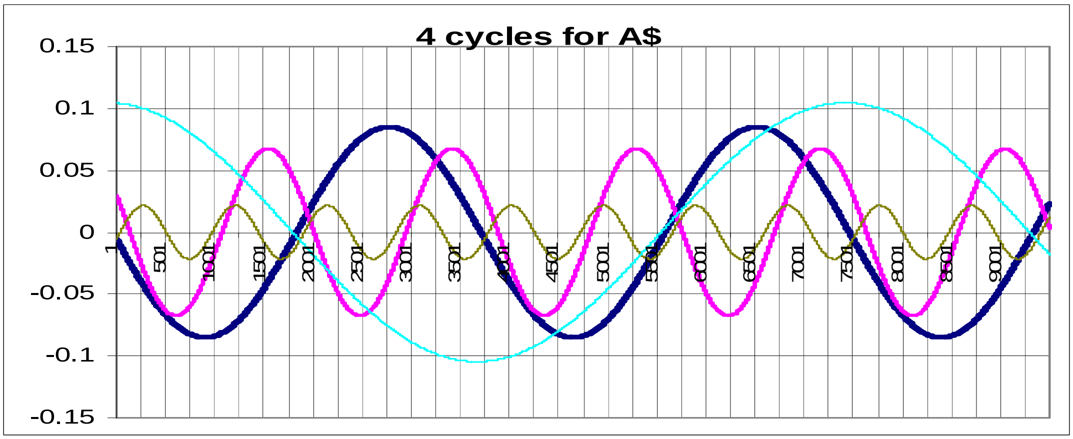
---

[6] However, as Cashin *et al* [6, p. 292] have remarked, "cycles in economic activity alone do not drive the evolution of commodity prices, and that other factors, particularly supply conditions in individual commodity markets, are likely to be a key determinant of cycles in commodity prices".

[7] A detailed analysis of all these issues is of course out of the scope of this paper which primarily sets the basis via some propositions for more research.

[8] Layton [18] supports this date of 1989/90 with his analysis.

Figure 3 **The 4 cycles determined by the OLS regression**



Notes: the higher the amplitude the higher the period of the cycle. Thus, the first peak of the 15 year cycle occurs on the 1510th day approximately or 1/1990. Every 250 days constitute on year on the x-axis. Thus the 5000th datum is in July 2003.

3. Econometric evidence

Fourier analysis is useful in many ways. In this paper this analysis will be used for 2 purposes. First, it will indicate econometrically how good is the assumption that the A$ can be overwhelmingly approximated by 4 cycles harmonic to each other. And second, it will indicate whether the cycles suggested in the discussion above can be confirmed through the calculation of spectra.

A few important points can summarize the Fourier analysis (see [7]; [3]) as used here. A time series f (t) can be fully represented by the sum of sinusoidal functions for all harmonic frequencies. Thus it becomes significant for our paper that if we can isolate only a few such sinusoidal functions that mostly explain the initial series f (t) (for example a high R^2 will indicate how important these cycles are) then we can provide evidence that our preliminary theoretical discussion contains some grains of truth. More precisely mathematically we can summarize the salient points of Fourier functions as follows:

$$f(t) = A + C\cos(\omega_0 t + \vartheta) = A + B_1\cos(\omega_0 t) + B_2\sin(\omega_0 t) \quad (1)$$

where C is the amplitude, ω_0 is the angular frequency (related to frequency f as in cycles per time by $\omega_0 = 2\pi f$; and $f = 1/T$, where T is the period of the cycle); and θ is the phase shift. When equation (1) is expressed as a function of both cosine and sine, and estimated in an ordinary least squares (OLS) regression the amplitude and phase shift, if needed, can be indirectly calculated as a function of B_1 and B_2. If we want to include more than one angular frequency, as in harmonics we can have multiples of ω_0 as in $2\omega_0$ or $3\omega_0$, etc. and run a multiple regression with as many independent variables as the number of harmonics plus the fundamental frequency ω_0.

The suggested best fit (see below the criteria of choosing the "best" fit) Fourier approximation of the Australian dollar by 4 harmonics is the one that uses as fundamental frequency 3.75 years (or 250 active days per year), hence the harmonics being 7.5 years, 15 years and 30 years. Figure 1 shows the raw data, the fitted 4-cycle sinusoidal fitted curve and predictions for the next 16 years[9].

The criteria for choosing the above fitted curve are the following:

A] The *a priori* justification on economic and econometric grounds (the commodity prices cycle; the commodity production cycles; the general economic cycles; the "mysterious" connections of harmonics).

B] The R^2 of Fourier regressions as shown in equation (1). See Table 1 below.

Table 1 Comparative data for 4 similar periods to 16 years

Period of cycle	**14**	**15**	**16**	**17**	**18**
R^2	0.78	0.86	0.88	0.83	0.80
Constant	0.725	0.751	0.790	0.862	0.966
When the 4 cycles cancel each other	0.83	0.74	0.67	0.51	0.34
Predictions (June, July, August, September 2005)	Under-estimating	Minimal error (almost 0% to 1% on average each month)	Over-estimating	Over-estimating even more	Over-estimating even more
Maximum peak at about 2010-2013	0.9 (in 2010)	0.98	1.1	1.3	1.6 (in 2013)

Note: the average of the whole sample from December 12, 1983 to May 26, 2005 is 0.707.

[9] It is well known that what we can do on the frequency domain we can also do on the time domain. Using the 140 quarters of real exchange rate from 1970 to 2005, similar results are obtained; the best fit is the regression that has as independent lagged variables those with 16, 31, 32, 64, and 128 quarters as significant lags (thus corresponding to 4, 8, 16, and 32 years of periods). To correct such a model for serial correlation, it was re-run by using the Cochrane-Orcutt method (as autoregressive of order 1); the coefficients remained approximately the same with no serial correlation and the R^2 remained high at about 0.90.

C] The out-of-sample performance of the model, both short run and long run. The short run is also a comparison of actual data with predicted data during the period June to September 2005. The results of this comparison are shown in Table 1. In the long run, it is expected that the Australian dollar will only approach the absolute equality of 1A$ to 1US$ but will not surpass it[10].

D] The value of the constant in the regression, again shown in Table 1. It is expected that this constant should not be too far away from the average over the whole set of data which is 0.707.

E] The significance of the phase between the 4 harmonic cycles (a hint on the differences of phase and some interpretation was given above).

F] The behavior of the residuals of regressions. The standard diagnostic tests of serial correlation, functional form, normality, and heteroscedasticity for the ordinary least squares (OLS) regression are as expected not good because the used model of the four sinusoidal independent variables of long cycles has ignored the very short influence of daily and weekly cycles. This can easily be fixed with the re-estimation of the model according to the Cochrane-Orcutt procedure. Effectively lags up to 3-6 days[11] completely eliminated the serial correlation and other related problems. In addition, some of the errors (when the daily and weekly cycles are not included in the original OLS model this becomes even more apparent) seem to well coincide with some ad hoc situations and events, and policy measures. For example, according to Makin [19, p. 336], “intervention was highest in July 1986 to prevent further depreciation by buying Australian dollars, but was also high in February 1989 to stem appreciation”. These two interventions agree with the magnitude and sign of the residuals of our model (negative during 1986 and positive during 1989). A detailed analysis of the residuals is nonetheless out of the scope of this paper.

G] The suggestion of cycles according to spectra. As already mentioned spectral analysis (based on Fourier analysis) can also be used to detect cycles of a time series. In order to have a longer span of time than the 22 years of daily floating Australian dollar, its real exchange rate[12] is used instead for which data are available on a

[10] This is of course a “gut feeling”.

[11] The original daily data were recalculated as 2-day averages thus reducing the original number of data from 5422 to 2711. The ensuing regressions with 2711 data produced as expected similar results and the lags in the autoregressive Cochrane-Orcutt scheme needed lags up to three 2-day data to eliminate serial correlation and related problems.

[12] Thus the use of real exchange rates provides similar results to those found for nominal exchange rates. This is not a surprising outcome for a commodity currency like the Australian dollar which

quarterly basis from June 1970 to June 2005 (N=140). The results are quite clear: significant peaks of the spectrum of this series are found for periods of about 30 and 15 quarters allowing for a reasonable window and according to all three approximations ("Bartlett", "Tukey", and "Parzen"). Peaks of periods of 60 and 120 quarters are also detected but these periods are only found if a larger window of the spectrum is used and hence their significance is less strong given the limited number of observations.

4. Conclusions

The review of the relevant literature has shown that most standard theories of the determination of exchange rates have failed to explain most issues concerning these rates. It seems that there is a now a relative consensus that some sort of non-linear inherent tendency could be the main force of driving trends and fluctuation of exchange rates. In particular the currencies that are now called commodity currencies, such as the Australian and Canadian dollars are heavily influenced by commodity prices. All this has led the author to investigate the possibility that the Australian dollar is primarily determined by a handful of harmonic cycles which in turn are based on the commodity prices cycles, commodity production cycles and in general on economic cycles that are suspected to be influenced by the commodity world.

Hence the proper econometric approach to this investigation was judged to be the well-known Fourier analysis according to which any time series can be represented by the sum of sinusoidal functions. The application of such analysis to the trend and fluctuations of this currency has produced some very interesting results. The four harmonic cycles used in this respect (3.75, 7.5, 15, and 30 years) explain 85% of the everyday changes of this commodity currency, the remaining being attributed to *ad hoc* situations, policy measures, and so on. These conclusions if true (many people would be very skeptical of such amazing results) have far reaching implications at least for commodity currencies.

depends on world trade for its determination (the real exchange rate is based on a real trade weighted index). It is also worth noting that since the real exchange rate goes further back from December 1983 (the date of floating the A$)-thus we have the period June 1970 to June 2005- and since the same cycles exist for this more extended period of time, it is possible to assert that the PPP hypothesis might be to some extent valid.

First, more investigations should concentrate on the underlying cycles of commodity prices, commodity production cycles (e.g. mining ones) in order to shed more light on the alleged relationship between all aspects of commodities and national currencies. In addition, economic cycles in general which have been neglected in the last 30 years or so should be further reconsidered. Second, we have to reassess what we mean by trend and stationarity in time series; for in our case the remaining 15% of unexplained variance seems to fluctuate around the 4-cycle “trend” as determined in this paper. Third, and as a consequence of the second implication, economic policy is rather powerless in strongly influencing the exchange rate in its floating state.

Fourth, theories such as the PPP version does not hold true at least in its traditional way of integer cointegration. Both this paper and [20] seem to support the idea that once we include low frequency dynamics and hence long period cycles the Australian dollar reverts back to its “mean”. Fifth and probably most important for many speculators, it is possible to predict quite accurately the long run behavior of the Australian dollar. Thus, it is recommended that for the time being let us hold our Australian dollars until about 2012 (the highest peak of the A$ appreciation); in that year we must start buying American dollars again.

References

[1] ACHIREKO, P.K., ANSONG, G. Stochastic model of mineral prices incorporating neural network and regression analysis. *Transactions, Institution of Mining and Metallurgy (Section A: Mineral technology)*. (2000), vol. 109, January-April, pp. A49-A54.

[2] BAJADA, C. Business Cycle properties of the legitimate and underground economy in Australia. *Economic Record*. 2003, vol. 79, no. 247, Dec, pp. 397-411.

[3] BLOOMFIELD, P. *Fourier Analysis of Time Series: an Introduction*. New York: John Wiley & Sons, 1976. ISBN 0-471-08256-2.

[4] CASHIN, P., CESPEDES, L.F., SAHAY, R. Commodity currencies and the real exchange rate. *Journal of Development Economics*. 2004, vol. 75, no. 1, pp. 239-268.

[5] CASHIN, P., McDERMOTT, C.J. The long-run behavior of commodity prices: small trends and big variability. *IMF staff Papers*. 2002, vol. 49, no. 2, pp. 175-199.

[6] CASHIN, P., McDERMOTT, C.J., SCOTT, A. Booms and slumps in world commodity prices. *Journal of Development Economics*. 2002, vol. 69, no. 1, pp. 277-296.

[7] CHAPRA, S.C., CANALE, R.P. *Numerical Methods for Engineers*. Boston: WCB/McGraw-Hill, 1998. ISBN 0-070-10938-9.

[8] CHEN, Y.C., ROGOFF, K. Commodity currencies. *Journal of International Economics*. 2003, vol. 60, no. 1, pp. 133-160.

[9] CORTAZAR, G., CASASSUS, J. Optimal Timing of a mine expansion: implementing a real options model. *The Quarterly Review of Economics and Finance*. 1998, vol. 38, Special Issue, pp. 755-769.

[10] DE GRAUWE, P., GRIMALDI, M. The Exchange rate and its fundamentals in a complex world. *Review of International Economics*. 2005, vol. 13, no. 3, pp. 549-575.

[11] FORRESTER, J.W. Business structure, economic cycles, and national policy. *Futures*. 1976, June, pp. 195-214.

[12] GRAEDEL, T.E., BERTRAM, M., FUSE, K., GORDON, R.B., LIFSET, R., RECHBERGER, H., SPATARI, S. The contemporary European copper cycle: the characterization of technological copper cycles. *Ecological Economics*. 2002, vol. 42, no. 1-2, pp. 9-26.

[13] HATZININIKOLAOU, D., POLASEK, M. The commodity-currency view of the Australian dollar: a multivariate cointegration approach. *Journal of Applied Economics*. 2005, vol. 8, no. 1, pp. 81-99.

[14] HENRY, O.T., OLEKALNS, N. Does the Australian dollar real exchange rate display mean reversion? *Journal of International Money and Finance*. 2002, vol. 21, no. 5, pp. 651-666.

[15] HUMPHREYS, D. Global industrial production and what it means for mining. *The Northern Miner*. 2003, vol. 89, no. 16, pp.4-6.

[16] KARFAKIS, C., PHIPPS, A. Modeling the Australian dollar-US dollar exchange rate using cointegration techniques. *Review of International Economics*. 1999, vol. 7, no. 2, pp. 265-279.

[17] LABYS, W.C., AFRASIABI, A. Cyclical disequilibrium in the US copper market. *Applied Economics*. 1983, vol. 15, no. 4, pp. 437-449.

[18] LAYTON, A.P. A new approach to dating and predicting Australian business cycle phase changes. *Applied Economics*. 1997, vol. 29, no. 7, pp. 861-868.

[19] MAKIN, T. The main determinants of Australia's Exchange rate. *The Australian Economic Review*. 1997, vol. 30, no. 3, pp. 329-339.

[20] MASIH, A.M.M., MASIH, R. Fractional cointegration, low frequency dynamics and long-run purchasing power parity: an analysis of the Australian dollar over its recent float. *Applied Economics*. 2004, vol. 36, no. 6, pp. 593-605.

[21] NGUYEN, V.N. Common trends in metal futures curves and inventories: evidence from the London Metal Exchange. *Derivatives use, Trading & Regulation*. 2004, vol. 10, no. 2, pp. 114-130.

[22] PYNNONEN, S., VATAJA, J. Bootstrap testing for cointegration of international commodity prices. *Applied Economics*. 2002, vol. 34, no. 5, pp. 637-647.

[23] RANKIN, B. The exchange rate and the Reserve Bank's role in the foreign exchange market. Canberra: Reserve Bank of Australia (RBA), May 1998. Access from: <http://www.rba.gov.au/education/exchange_rate.html>

[24] Reserve Bank of Australia (RBA) Bulletin. *Modifications to the reserve Bank of Australia's Commodity price Index*. 1998, September.

[25] Reserve Bank of Australia (RBA): Access from: <http://www.rba.gov.au/Statistics/AlphaListing/alpha_listing_e.html >

[26] Western Mining Corporation (WMC). Access from: Originally in http://www.wmc.com/acrobat/pacrim20040922.pdf ; and then in general from: <http://www.wmc.com/bb/search/home.jsp>