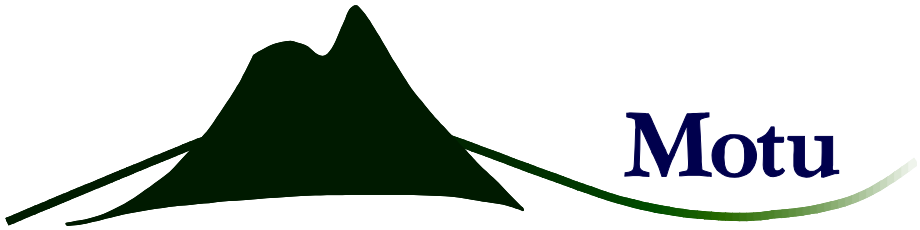


Uncovering uncovered interest parity during the classical gold standard era, 1888-1905

Andrew Coleman

Motu Working Paper 10-02
Motu Economic and Public Policy Research

May 2010

Author contact details
Andrew Coleman
Motu Economic and Public Policy Research
andrew.coleman@motu.org.nz

Acknowledgements
I would like to thank Arthur Grimes and Marianna Kennedy for useful comments.

Motu Economic and Public Policy Research
PO Box 24390
Wellington
New Zealand

Email info@motu.org.nz
Telephone +64 4 9394250
Website www.motu.org.nz

 ISSN 1176-2667 (Print), ISSN 1177-9047 (Online).

Abstract
This paper examines the uncovered interest parity hypothesis using the dollar-sterling exchange rate during the gold standard era. This period is interesting because the exchange rate was seasonal, because transactions costs were high, and because occasions when uncovered interest rate speculation did not occur can be identified. The paper shows UIP speculation frequently did not occur, that speculation occurred more in response to expected exchange rate changes than interest rate differentials, and that profitability varied systematically with interest rate differentials. The estimated UIP equations are substantially improved by distinguishing occasions when sterling was borrowed not lent.

JEL codes
N21, F31

Keywords
Uncovered interest parity, gold standard

Summary Haiku

When New York bankers
bought sterling low, or sold high,
they made good profits.

Contents

1. Introduction 1
2. The New York sterling bill market 5
3. Econometric methodology 8
4. Data 11
5. Uncovered interest parity, 1897- 1905 12
6. Uncovered interest parity, 1888 – 1896 16
7. Conclusions 19

1. Introduction

One of the standard puzzles in international finance concerns the uncovered interest rate parity hypothesis. According to the hypothesis, if speculators are risk neutral and have rational expectations, for every percent that the interest rate on an n-year maturity domestic currency security exceeds the interest rate on a foreign currency security with the same maturity, the currency should be expected to depreciate by n percent over the subsequent n years. Yet when the change in the spot exchange rate is regressed against the interest rate differential, the slope of the regression is typically negative for most currencies and periods, rather than one. This result is puzzling, as it suggests that significant speculative profits have been available to those who issue securities denominated in a low yielding currency in order to purchase securities in a high yielding currency.[1] The failure of uncovered interest parity to hold is particularly acute for short maturity instruments.

Analysts have suggested several ways to reconcile the empirical results with the uncovered interest parity hypothesis. If speculators are not risk neutral, for example, but demand a time varying risk premium to hold securities issued in a particular currency, a regression of the change in the spot exchange rate against the interest rate differential would be misspecified as it excludes the risk premium. In turn, the coefficient would be negatively biased if the risk premium were positively correlated with the foreign interest rate (Fama 1984). The estimated coefficient may also be biased if expectations are not rational, or the econometrician poorly captures the way expectations are formed. If agents have expectations of a currency depreciation that never occurs, for example, the distribution of the actual exchange rate changes will differ from the distribution of the expected exchange rate changes, inducing a negative bias in the regression (the peso problem). Alternatively, it is possible that uncovered interest parity speculation simply does not occur in the postulated manner. Firms may be limited in the extent to which they can borrow in one currency to invest in another, or may be unwilling to invest in foreign securities if other opportunities are perceived to be better. For this reason, recent research has tried to ascertain the conditions under which agents take speculative positions to take advantage of interest rate differentials, rather than simply assess the extent to which uncovered interest parity regressions fail to hold.

This paper examines how well the uncovered interest parity hypothesis held for U.S. dollar and sterling denominated securities during the classical gold standard era. The primary aim is to establish whether the peculiar structure of this market can shed light onto the reasons why

[1] For a review of the literature, see Engel (1996).

speculators sometimes engage in currency speculation, and why the empirical fit of the uncovered parity relationship is so poor for short maturity interest rates.

There are five reasons why this period is particularly suited to this investigation. First, the market was geographically compact. The dollar-sterling foreign exchange market consisted of the New York market for sterling bills, as U.S. bills were not used to finance either trade or international investment flows. Consequently, all financial speculators are likely to have had the same opportunities and to have faced the same constraints.

Secondly, the exchange rate varied seasonally due to seasonal variation in trade flows. Typically the dollar was strong in the fall, when exports of cotton and grain took place, and weak in spring when exporting activity was low and remittances were high. Contemporary reports suggest that New York domiciled investment banks often took positions in the sterling bill market to take advantage of fluctuations in the supply of bills caused by the seasonally varying trade flows. They bought sterling bills in the fall when they were common and their price was low, and borrowed sterling in summer, repaying the loans with cheap sterling two or three months later.

Thirdly, the exchange rate market had high transactions costs. While U.S. investment banks could purchase sterling bills at almost no cost, if they issued sterling bills drawn against a London bank they were charged a fee equal to 1.8% (annualized) of the principal. Thus there was a large price wedge between the returns from borrowing U.S. dollars to invest in sterling bills, and the returns from borrowing sterling to invest in U.S. dollar denominated bills. This wedge means that speculation would have only taken place if expected returns were large enough to offset transactions costs.

Fourthly, it is possible to identify occasions when financial speculation did not equate dollar and sterling returns (adjusted for transaction costs). In a flexible exchange rate regime the exchange rate changes until the marginal agent is indifferent between holding either of the two currencies. Under the gold standard, this was not true. If the New York price of sterling rose sufficiently high, agents in New York would ship gold to London where it could be used to purchase sterling securities. Conversely, if the New York price of sterling dropped sufficiently low, gold would be shipped from London to New York and transformed into dollars. On both occasions, gold was shipped at a price at which financial speculators were not prepared to issue or hold further sterling securities. These dates provide an interesting test of the uncovered interest parity as they can be used to trace out a locus of values at which uncovered interest parity is known not to have held.

Fifthly, the period demonstrates the importance of the peso problem in explaining why empirical tests of uncovered interest parity generally do not hold (Hallwood, MacDonald, Marsh 2000). Prior to 1896 it was widely believed that the U.S. would be forced to change the mint parity rate because of legislative requirements that the U.S. Treasury purchase large quantities of silver. This realignment never occurred and in November 1896 McKinley's election victory ended speculation that the mint parity rate would change. By examining the periods before and after November 1896, it is possible to ascertain the effect of the peso problem on the uncovered interest parity relationship.

The paper uses several aspects of this market structure, particularly the high transactions costs, the gold-trade, and the seasonal nature of the exchange rate, to analyze the uncovered interest parity relationship. The main hypothesis is that expected returns and the intensity of speculative behaviour varied over time, affecting the extent to which simple estimates of the uncovered interest parity relationship should hold. Financial speculators were often but not always active in the foreign exchange market, sometimes purchasing sterling bills when expected returns from holding sterling were high, sometimes issuing sterling bills when the expected returns from holding sterling were low, but sometimes having a very small role. When simple regression analysis is used to estimate the relationship between interest rate differentials and subsequent exchange rate movements, the slope coefficient reflects an average that makes no allowance for differences in the intensity of speculative behaviour or for differences in expected returns. When allowances are made for these factors, the empirical relationship suggests that cross-currency arbitrage was often profitable, and that the interest rate differential and subsequent exchange rate movement had the correct sign, even if they did not fully offset each other.

Three results of the paper should be highlighted. First, a naïve uncovered interest parity regression using all weekly data from 1897-1905 for sixty day interest rates has a slope of 0.44, and is significantly greater than zero and significantly less than 1. This slope is much larger than those usually estimated for short term interest rates. Nonetheless, it represents the average of two different regressions: a regression using dates when gold exports or imports occurred, and when uncovered interest parity is known not to have occurred, and dates when there was no gold trade. Somewhat paradoxically, the simple regression slope on the dates when uncovered interest parity is known not to have occurred is 0.98 (with a standard error of 0.3), while the slope on other dates is 0.34 (with a standard error of 0.15). The paradox is more apparent than real, however, for the dates on which gold exports and imports occur should trace out a locus of

boundary points at which speculation is not quite profitable. This regression generates transactions cost estimates very close to that given in the contemporary literature.

Secondly, when the sample is restricted to dates in the fall, when the price of sterling was low and when many agents purchased sterling bills because their price was expected to rise, the estimated slope was 0.58 (standard error of 0.18), larger than at other times of the year. The results further suggest that week-by-week variation in the risk premium equivalent to approximately 1 percent per annum was enough to spark gold imports.

Thirdly, the regressions suggest that identifying times when speculators borrowed rather than purchased sterling has the potential to significantly improve the explanatory power of uncovered interest parity regressions. When the seasonality of the market is used to crudely identify when speculators were borrowing, and when an allowance is made for the different transactions costs of borrowing or lending, the slope coefficient of the uncovered interest parity regression increases significantly and the fraction of the variance of the regression that is explained increases from 2 percent to 36 percent. Perhaps surprisingly, speculators tended to invest in sterling when U.S. interest rates were relatively high, and borrow sterling when U.S. interest rates were relatively low. Exchange rate expectations rather than interest rate differentials appear to have driven profitable speculation in this market.

Collectively, these results suggest that financial arbitrage was more efficient than the simple uncovered interest parity regression would suggest. Agents appear to have been selective about the times they speculated on the foreign exchange market. They were at pains to ensure expected returns from speculation exceeded transactions costs. Financial speculation often did not, at the margin, determine the exchange rate. Finally, even though expected changes in sterling rates did not fully offset interest differentials, a one percentage point widening of the interest rate differential on average was associated with a 0.5 percentage point increase in expected returns.

The paper is structured as follows. Section 2 provides details about the operation of the exchange rate market during the gold standard era. Section 3 outlines the econometric models that are estimated, while section 4 describes the data. The main results covering the period 1897-1905 are presented in Section 5, while the results for the period 1888-1896 are presented in section 6. Finally, conclusions are offered in section 7.

2. The New York sterling bill market

The basic structure of the dollar-sterling market has been outlined by Goodhart (1969), Foster (1994), and Officer (1996), and a detailed exposition is available from a clutch of contemporary texts including Margraff (1904), Escher (1913), Whitaker (1920) and York (1923). The dominant foreign exchange security during the period was the sterling bill, a cheque-like instrument that promised payment in sterling by a London bank a certain number of days after delivery in London. Demand or sight bills were payable immediately; sixty day bills were payable sixty days after delivery. During the period, three types of sterling denominated bills were used to settle most international commercial and financial transactions. The first type was the bill of exchange, a promise to deliver sterling in London made by an importer and given to the exporter as payment for merchandise. The second type was a security-backed bill, a promise to deliver sterling in London made by the purchaser of U.S. financial securities and given to the U.S. broker in payment for the securities. The third type was a bank bill, a promise to deliver sterling in London made by a bank. While equivalent classes of bills were denominated in francs and marks (and redeemable in Paris and Berlin), a market for U.S. dollar denominated paper did not exist in London or Europe. Consequently, all dollar-sterling arbitrage activity revolved around the New York market for sterling exchange.

It is widely recognized that the seasonality of the dollar-sterling exchange rate reflected the seasonality of United States exports[2]. Because US exports were dominated by primary agricultural products, the trade balance had a seasonal peak in the three months to November and a trough in the three months to August. Since the exports were paid for with sterling denominated bills of exchange, the supply of sterling bills of exchange varied seasonally. In turn the price of sterling bills varied seasonally, reaching a peak in spring and a trough during the fall.

The exchange rate swings were limited by the possibility of gold arbitrage. Since both the dollar and the pound were convertible into gold, if the price of a sight bill deviated too far from the mint parity rate of $486.65 per pound it was possible for agents to purchase gold from the monetary authority in one country, ship it across the Atlantic, and sell it to the monetary authority in the other country.

Coleman (2007) used several contemporary sources to identify the weeks in which gold was sent between New York and London as an exchange rate arbitrage operation between 1886 and 1905. Such operations occurred on approximately twenty percent of all weeks. Arbitrage operations were sometimes conducted indirectly, with arbitrageurs exporting gold to Paris or

[2] See Kemmerer (1910), or various references in Goodhart (1969), or Foster (1994).

Berlin where it was used to purchase sterling exchange rather than exporting gold to London directly'[3]. The rates at which it was profitable to ship gold between New York and London were known as the gold points. From 1886 - 1896, the average gold export point was $4.893, while the average gold import point was $4.838; the gold points narrowed after 1896.

The quantity of gold shipped depended on the quantity of finance operations. Rather than export gold in summer only to import it back in fall, New York banks were able to supplant the shortage of sterling trade bills in summer by selling sterling finance bills[4]. By making a use of sterling loan from a London bank, they would sell a three month sterling bill in New York in summer at a high price, invest the proceeds, and purchase a sterling trade bill in the fall at a low price to pay back the loan. The transaction would be profitable so long as the depreciation in sterling was greater than the difference in the two interest rates. Conversely, in fall arbitrageurs could purchase long dated sterling bills at a low price, with the intention of selling them later at a profit.

This process is, of course, a simple example of uncovered interest arbitrage. Goodhart (1969) observed that the relationship was well understood at the time, and frequently practiced. York (1923, p 135) noted that American borrowers of London funds would most frequently take uncovered positions in the late spring, in the anticipation that the price of sterling would be lower when repayment was due because of the export of cotton and grain. Escher (1913 p96) also describes the practice of selling finance bills in summer, noting that while it was "plain speculating in exchange", many of the big houses engaged in it. He further noted that the practice was conducted throughout the year. Contemporary newspapers also described the operation. In January 1887, for instance, the Commercial and Financial Chronicle noted a 1.5 cent rise in sterling from near the gold import point because of speculative purchases of long sterling bills by bankers:

"Some bankers have also bought for speculation, procuring cheap bills and intending to hold them for a profit. The reasons which have induced these purchases are not far to seek. As an investment the security is ample. We have now reached the period of the year when exports would naturally fall off, and other things being equal exchange would rise; hence the chances of profit resulting from the holding of long sterling till it matures are good." (Commercial and Financial Chronicle, 44 (1125) [January 15 1887] p70).

[3] Most indirect arbitrage occurred after 1900, following the Bank of France's decision to stop charging a premium for foreign gold. This reduced the demand for sterling in Paris and meant that sterling frequently sold at a steep discount. US banks found it cheaper to send gold to Paris and buy discounted sterling than it was to send gold to London directly.

[4] See Goodhart (1969: Chapter 2), quoting Margraff (1904); also Escher (1910: Chapter 6), Whitaker (1919, Chapters 12 and 13), York (1923: Chapter 23).

Goodhart argued that financial arbitrage appears to have been more important than gold shipments. He noted that while the trade balance averaged $76 million per month in the three months to December, compared to $18 million per month in the three months to August, average gold imports in the three months to December were only $4.8 million, compared to average gold exports of $0.3 million in the three months to August. Given the difference in these flows is only a tenth of the difference in the current account position it suggests most of the current account seasonality was financed by other means.

Nonetheless, there were limits to the extent which financial arbitrage occurred. If a U.S. bank borrowed sterling by issuing a finance bill on its own account, it had to pay a significant transactions fee. The U.K. Treasury charged a flat stamp duty of 0.05% (equivalent to 0.3% p.a.. interest for a sixty day bill); in addition the British bank that accepted the bill charged a fee of up to 1/8% per month (equivalent to 1.5% p.a. interest.)[5] Given these transactions fees, there would be times when even risk neutral speculators would not find it advantageous to speculate. These costs would obviously be lower if British banks issued finance bills on their own account in order to invest in U.S. time paper. However, U.S. dollar and sterling paper were far from perfect substitutes so British banks were reluctant to hold too much U.S. dollar paper. Moreover, as stated by Escher (1910 p91-92) and argued at greater length by Foster (1994 p162-164, 172) there were limits to the volume of finance bills that a U.S. bank could issue. British banks were only willing to accept a certain amount of paper issued by U.S. banks, for fear that their own name would be sullied if they guaranteed too much.

U.S. dollar and sterling paper differed in terms of security and liquidity. Most sterling loans not only had the security of the borrower but were guaranteed by the British accepting bank as well and thus were considered to have prime status[6]. In contrast a time loan made on the New York market was normally only secured by the financial stock purchased by borrower and was thus less secure than a sterling bill. In addition, sterling paper had greater liquidity than U.S. dollar paper. The Bank of England stood ready to discount most sterling paper that had been accepted by a recognized British bank, and thus sterling paper was extremely liquid. In contrast, not only did the U.S. not have a central bank, but most banks were not prepared to sell their own loans as it was seen as a sign of weakness. These two differences mean that for most of the

[5] York (1923 p133) quotes a commission of 1/8 to ¼ percent for a sixty day bill. Whitaker (1919, p367) quotes 1/8% per month. Foster (1994, p28) has a lengthy discussion and concludes that the commission varied from an interest rate equivalent of 0.5% to 1.5%.

[6] Payment of a bill of exchange was guaranteed by the importer as well as the exporter and, if the bill was accepted by the importer's U.K bank, a U.K. bank as well. In addition, until acceptance the purchaser of the bill had ownership of the exports as collateral.

period U.S. dollar sixty day time loan rates were higher than sterling sixty day discount rates (see Figure 1).

This paper is not the first investigation of the uncovered interest parity proposition using gold standard era data. Goodhart (1969: Chapter 2) used monthly data to examine the seasonality of interest rates, exchange rates, and gold flows during the period 1900 – 1913. He noted that on average the three-month change in the price of sterling was negative between May and September, when the difference in U.S. dollar and sterling interest rates was small, and positive from October through April, when the difference in interest rates was much larger. This is evidence that uncovered interest rate parity held to some extent. Nonetheless, he calculated that the combination of interest margin plus expected currency depreciation (with the expected margin replaced by the average actual margin in the calculation) was too small to explain why capital flowed to the United Kingdom in the summer and to the United States in the fall, and thus concluded (without formally testing the result) that speculative opportunities remained unexploited. Foster (1994: Chapter 5) also examined whether the seasonality of interest rates and exchange rates during the period was consistent with markets efficiently exploiting speculative opportunities. Using monthly data, she calculated the difference between U.S. dollar and sterling interest rates, and showed that there was a marked seasonal pattern. She then calculated the difference in the interest rates, adjusting for ex–post exchange rate movements, and showed this series had greater seasonal variation. She noted that if uncovered interest rate parity held, the difference between interest rates, adjusted for exchange rate movements would not be seasonal, and thus concluded that speculative opportunities seemed not to have been realized.

3. Econometric methodology

Let S_t = the spot price in U.S. dollars of a £1 sight bill

s_t = $ln(S_t)$

r_t^{US} = sixty day U.S. dollar interest rates at time t

r_t^{UK} = sixty day sterling interest rates at time t

n = maturity of the bill, n = 60/365

θ_t = risk premium or the excess return necessary to induce agents to hold sterling rather than dollar bills.

T^b, T^s = transaction cost to buy or sell (borrow) a sterling bill.

The risk premium θ can be positive or negative, and on average is negative in the sample as U.S. dollar paper was considered riskier than sterling denominated paper.

3.1. The purchase of sterling securities.

Suppose agents speculate in the foreign exchange market by purchasing sterling bills. Then

$$r_t^{UK} + \frac{1}{n}(E_t[s_{t+60}] - s_t) \geq r_t^{US} + \theta_t + T^b \quad (1a)$$

with the inequality holding with equality if speculators enter the market until the risk adjusted returns from sterling and dollar denominated securities are identical. Equivalently,

$$E_t[s_{t+60}] - s_t \geq n(r_t^{US} - r_t^{UK}) + n(\theta_t + T^b) \quad (1b)$$

Further, if expectations are rational,

$$s_{t+60} = E_t[s_{t+60}] + e_{t+60} \quad (2)$$

Hence, if agents buy sterling to equate returns in the two currencies,

$$s_{t+60} - s_t = n(r_t^{US} - r_t^{UK}) + n(\theta_t + T^b) + e_{t+60} \quad (3)$$

3.2. The issue of sterling securities

Suppose agents speculate in the foreign exchange market by issuing sterling securities. Then

$$r_t^{UK} + \frac{1}{n}(E_t[s_{t+60}] - s_t) \leq r_t^{US} + \theta_t - T^s \quad (4a)$$

with the inequality holding with equality if speculators enter the market until the risk adjusted returns from sterling and dollar denominated securities are identical. Equivalently,

$$E_t[s_{t+60}] - s_t \leq n(r_t^{US} - r_t^{UK}) + n(\theta_t - T^s) \quad (4b)$$

Again, if expectations are rational, and agents issue sterling to equate returns in the two currencies,

$$s_{t+60} - s_t = n(r_t^{US} - r_t^{UK}) + n(\theta_t - T^s) + e_{t+60} \quad (5)$$

When equations (1b) and (4b) hold with equality, they define the loci of points at which agents are just indifferent between buying sterling bills or issuing sterling bills rather than investing in U.S. bills.

3.3. Gold imports and exports

As described in section 2, agents did not always equate U.S. dollar and sterling returns. In particular, gold imports occurred when the price of sterling bills was insufficiently low to induce financial speculators to purchase sterling bills, but sufficiently low to make gold arbitrage profitable. On these dates,

$$E_t[s_{t+60}] - s_t < n(r_t^{US} - r_t^{UK}) + n(\theta_t + T^b) \quad (6)$$

Similarly, gold exports occurred when the price of sterling bills was insufficiently high to induce financial speculators to issue sterling bills in the hope of a subsequent depreciation, but sufficiently high to make gold arbitrage profitable. On these dates,

$$E_t[s_{t+60}] - s_t > n(r_t^{US} - r_t^{UK}) + n(\theta_t - T^s) \quad (7)$$

If the risk premium were constant, equations 6 and 7 would lie on the inside of the lines traced out by equations 1b and 4b (see figure 2).

3.4. Econometric strategy

Since expected future exchange rates are unknown to the econometrician, the standard approach is estimate equations 3 and 5 under the assumption that exchange rate expectations are rational and that returns from U.S. dollar and sterling returns are equalized:

$$s_{t+60} - s_t = \alpha + \beta n(r_t^{US} - r_t^{UK}) + \nu_{t+60} \quad (8)$$

Compared to the pair of equations (3) and (5), this equation omits both the transaction cost and risk premium terms, incorporating them in the error term ν. If the terms θ, T^b, or T^s are uncorrelated with the interest differential $r_t^{US} - r_t^{UK}$, their omission will merely raise the standard error of the slope coefficient. If they are correlated with the interest differential, however, they will bias the estimated coefficient. This bias is possible for two reasons. First, the increase in the risk premium may be positively correlated with sterling interest rates, or negatively correlated with U.S. dollar interest rates. If so, the OLS estimate of the coefficient β will be biased

downwards. Secondly, the appropriate transactions cost at time t (T^b if purchasing bills, T^s if issuing bills) will be negatively correlated with the interest differential if agents borrow sterling when the interest differential is high and buy sterling when the interest rate differential is low. This will also induce a negative correlation in the estimated coefficient. In fact, as we demonstrate below, during the gold standard era agents typically purchased sterling bills when the interest rate differential was large, in the fall, and borrowed sterling when the differential was small, in summer, inducing a positive bias in the coefficient.

The econometric approach is straightforward. Variants of equation 8 are estimated using ordinary least squares for different subsets of the data. The subsets are chosen to distinguish observations that differ by transactions costs or other criteria, and dummy variables are included in the regression to allow for differences in transactions costs or the risk premium. The estimated standard errors of the regression are adjusted for serial correlation in the error structure, because the regression uses the nine week change in the exchange rate but the data are sampled weekly. The adjustment is made using the Newey-West (1987) heteroskedasticity and autocorrelation consistent standard error estimator, allowing for an eight week lag[7]. The estimated Newey-West standard errors are often more than double the OLS estimated standard errors.

4. Data

The regressions are conducted separately for the periods 1888-1896 and 1897-1905, because of the peso problem (see section 6.) Coincidentally, separate sources were used to collect the data pre-1896 and post 1896, so the sources are discussed separately.

4.1. 1897- 1905

The exchange rate and U.S. interest rate data are sourced from Andrew (1910a). The U.K. interest data are sourced from Andrew (1910b). The exchange rate is the mean sight exchange rate for the week, calculated as the average of the maximum and minimum of the daily rates for each day of the week. The difference in exchange rates nine weeks apart was used as the difference in the exchange rates. The U.S. interest rate is the mean of the weekly range of the sixty day time loan rate. The U.K. interest rate is the mean of the weekly range of the sixty day discount rate.

[7] The Newey-West estimator is calculated taking into account the non-standard sampling pattern. Each of the regressions reported below is estimated in a block system that simultaneously uses all the data. (For example, the regression using dates when gold was traded is estimated simultaneously with the regression using dates when gold was not traded.) The errors from the block regression are used to calculate the Newey-West standard errors.

The data are divided into two groups: those dates on which gold was shipped as a dollar sterling exchange arbitrage action, and those dates on which it was not, using the dates identified in Coleman (2007) using a mixture of contemporary sources, primarily the Commercial and Financial Chronicle and the Economist magazine. There were 41 weeks during which gold was exported, 44 weeks when gold was imported, and 350 weeks when gold was not shipped. In addition there were 34 weeks for which interest rate data was not available: these dates were dropped. Most of these dropped dates reflect periods of stress in the New York money market when no activity in sixty day time loans were recorded: rates were reported to be nominal only, or were simply not reported. On some occasions a commission was charged in addition to the interest rate[8]. On these occasions the commission was annualized. Two additional observations, when U.S. interest rates were calculated to be in excess of 12 percent, were dropped as outliers.

4.2. 1888-1896

The exchange rate data in Andrew (1910a) is not suitable, as prior to January 1896 only retail rates, not wholesale rates are quoted. Alternative data was collected from the daily issues of the New York Times. U.S. interest rates (60 day time loans) are from Andrew (1910a) for the period 1890 – 1896; for 1888 and 1889 the data is from the contemporary issues of the Financial and Commercial Chronicle. Data prior to 1888 was only occasionally printed in the Chronicle, and thus earlier data was not used. U.K. interest rates (discount rate on sixty day bills) was from Andrew (1910b) for the period May 1890 – 1896; contemporary issues of the Economist magazine January 1890 – May 1890; and contemporary issues of the Commercial and Financial Chronicle for 1888 and 1889. The dates on which gold shipments occurred are documented in Coleman (2007). There were 76 weeks during which gold was exported, 26 weeks when gold was imported, and 321 weeks when gold was not shipped. In addition there were 35 weeks for which interest rate data was not available: these dates were dropped. Eleven additional observations, when U.S. interest rates were calculated to be in excess of 12 percent, (primarily in July 1893 and August- October 1896) were dropped as outliers.

5. Uncovered interest parity, 1897- 1905

In this section, a sequence of uncovered interest parity regressions for different subsets of the data are presented. In the first regression all of the data are included; in the second set, just the dates on which gold exports and imports took place; in the third set, data from the fall months September – November, when a large number of sterling bills were sold; and in the

[8] A commission would be charged to circumvent usury laws that otherwise capped loan rates at 6 percent.

fourth set, data from December – August, with particular emphasis on the months of July and August when investment banks often borrowed sterling to invest in U.S. dollar securities.

5.1. All data, 1897- 1905

Figure 3 shows a scatter plot of the data. The basic uncovered interest parity regression including data from all weeks, 1897- 1905 is

$$\begin{array}{l} s_{t+60} - s_t = -0.0007 + 0.44[n(r_t^{US} - r_t^{UK})] + v_{t+60} \qquad R^2 = 0.07 \\ \qquad\qquad (0.0004) \quad (0.16)^{**} \qquad\qquad\qquad\qquad\qquad n = 435 \end{array} \tag{9}$$

The estimated slope is 0.44, significantly different from both 0 and 1.

This regression can be considered an average of two separate regressions, one using data corresponding to the dates that gold shipments took place (and thus on which uncovered interest parity did not hold), and one using data on the non-shipment dates. The non-shipment regression is

$$\begin{array}{l} s_{t+60} - s_t = -0.0008 + 0.34[n(r_t^{US} - r_t^{UK})] + v_{t+60} \qquad R^2 = 0.045 \\ \qquad\qquad (0.0004)^{*} \quad (0.15)^{*} \qquad\qquad\qquad\qquad\qquad n = 350 \end{array} \tag{10}$$

The estimated slope is 0.34, smaller than when all data are used, but still significantly different from both 0 and 1.

5.2. Gold shipment dates, 1897-1905

Figure 4 shows a scatter plot of the data. The naïve uncovered interest parity regression is

$$\begin{array}{l} s_{t+60} - s_t = -0.0008 + 0.98[n(r_t^{US} - r_t^{UK})] + v_{t+60} \qquad R^2 = 0.23 \\ \qquad\qquad (0.0007) \quad (0.32)^{*} \qquad\qquad\qquad\qquad\qquad n = 85 \end{array} \tag{11}$$

This regression is misspecified, for the data should be tracing out loci indicating the lower bound of the region in which it is profitable to buy sterling paper, and the upper bound of the region at which it is profitable to issue sterling paper rather than a single equation. These loci should be separated by the sum of the transactions costs for buying and issuing sterling bills, 1.8 percent annualized or 0.003 for two months. When a dummy variable indicating whether an observation is a gold export or a gold import is included, the regression is

$$\begin{array}{l} s_{t+60} - s_t = 0.0013 + 0.50[n(r_t^{US} - r_t^{UK})] - 0.0028\,Gold\ Export + v_{t+60} \qquad R^2 = 0.44 \\ \qquad\qquad (0.0006)^{*} \quad (0.24)^{*} \qquad\qquad (0.0006)^{**} \qquad\qquad\qquad\qquad n = 85 \end{array} \tag{12}$$

While the coefficient reduces to 0.50, the most noticeable feature of the regression is the size of the estimate on the "gold export" dummy: in absolute terms it is almost exactly 0.003, the figure given in the contemporary literature as the cost of issuing a sterling bill. This coefficient is quite precisely estimated and suggest that the data are in fact tracing out two quite separate lines. When the "gold export" coefficient is restricted to -0.003, the regression is

$$\begin{array}{lll} s_{t+60} - s_t = -0.0008 + 0.48[n(r_t^{US} - r_t^{UK})] - 0.003\,Gold\ Export + v_{t+60} & R^2 = 0.42 \\ \qquad\quad (0.0004)^{*} \quad (0.27) & n = 85 \end{array} \tag{13}$$

Figure 4 shows that the interest differential was typically lower when gold exports took place than when gold imports took place. (This is because most gold imports took place in the fall, when there was a seasonal drain on the money markets due to the pressure to move crops.) Since the gold import locus is lower than the gold export locus, this will induce an upward bias in the naive uncovered interest parity regression that excludes the gold export dummy variable. As such, the coefficient of 0.98 estimated in the simple gold trade regression should not be considered the gold standard of uncovered interest parity regressions.

Overall, these regressions show the importance of being able to identify the occasions when speculators are likely to be borrowing rather than lending the foreign currency. Failure to account for this difference can lead to considerable bias in the estimated coefficients if transactions costs are high. A similar bias is likely to be induced if there are other factors that mean speculators demand different returns when buying or issuing foreign currency denominated instruments.

5.3. Fall trade, 1897-1905.

Figure 5 shows a scatter plot of the data on dates when there were either no gold shipments or gold imports in September, October, and November. The associated regression including a dummy variable for dates when gold imports occurred is:

$$\begin{array}{lll} s_{t+60} - s_t = -0.0010 + 0.58[n(r_t^{US} - r_t^{UK})] + 0.0016\,Gold\ imports + v_{t+60} & R^2 = 0.23 \\ \qquad\quad (0.0006) \quad (0.18)^{**} \qquad\quad (0.0006)^{*} & n = 102 \end{array} \tag{14}$$

The slope coefficient, 0.58 is again significantly different from 0 and 1, but higher than the coefficients estimated for other months. The large value may reflect the more intensive speculative activity that took place in the fall, due to the surplus of sterling trade bills.

The coefficient on the gold imports dummy variable is 0.0016, or 1.0% annualized, and is quite precisely estimated. This value is surprising, as gold was imported when the risk-adjusted expected return from sterling bills was insufficient to induce agents to buy them. Since the

average return on dates when gold was imported was higher than the average return when gold was not shipped, and since expected risk adjusted returns should have been lower, the coefficient provides a minimum estimate of the risk premium prevailing on dates that gold was imported. Consequently, it appears that gold imports typically occurred in the fall when the risk premium or required return to hold sterling bills increased by 1 percentage point, compared to an average return of 3 – 4 percent.

5.4. Non-shipment dates, December – August, 1897-1905.

While contemporary reports emphasize that speculative activity was most intense during the fall months, financial speculation occurred throughout the year. However, it is difficult to explicitly identify whether speculators were active on any particular date, and if so whether they were buying sterling or borrowing sterling. Without this information, a simple uncovered interest parity regression is likely to be biased and uninformative.

The uncovered interest parity regression for the non-shipment dates, December - August is:

$$\begin{array}{l} s_{t+60} - s_t = -0.0006 + 0.21[n(r_t^{US} - r_t^{UK})] + v_{t+60} \qquad R^2 = 0.02 \\ \qquad\qquad (0.0004) \quad (0.19) \qquad\qquad\qquad\qquad\qquad\quad n = 270 \end{array} \tag{15}$$

The slope of this regression cannot be distinguished from zero. The data can be split three ways, however; dates in July and August, when contemporary reports suggest speculators borrowed sterling; dates from December to May, which can be considered "ordinary" months; and dates in June, which appear to be a cross-over month. (If June is included in December and May the results are qualitatively similar, although the estimated slope coefficient is smaller.) Combining the December – May and July-August data, and allowing for "July-August" dummy variable to capture the different transactions costs associated with borrowing and lending sterling, the regression is:

$$\begin{array}{l} s_{t+60} - s_t = 0.00020 + 0.37[n(r_t^{US} - r_t^{UK})] - 0.0033 \text{ "}July - August\text{"} + v_{t+60} \qquad R^2 = 0.36 \\ \qquad\qquad (0.0004) \quad (0.12)^{**} \qquad\qquad (0.00045)^{*} \qquad\qquad\qquad\qquad\quad n = 240 \end{array} \tag{16}$$

The regression for the June data has a large negative slope, possibly because agents borrowed sterling (at high transactions cost) when pressure on the money markets for money to move crops was intensifying, simultaneously raising U.S. dollar interest rates and expectations for a large decline in sterling in the fall:

$$s_{t+60} - s_t = 0.0008 - 1.27[n(r_t^{US} - r_t^{UK})] + v_{t+60} \qquad R^2 = 0.31$$
$$(0.0006) \quad (0.36)^{**} \qquad n = 30 \tag{17}$$

The inclusion of a transaction cost "July-August" dummy variable in regression 16 vastly improves the fit of the regression. The estimated slope increases from 0.21 to 0.37, a figure that is statistically different from both 0 and 1, and the estimate of the dummy variable coefficient is –0.0033 or 2.1% annualized, similar to the other estimates and close to the value given by the contemporary literature. In this case, because it was expensive to borrow sterling and because agents borrowed sterling when the U.S. interest differential was high, failure to include a transactions cost dummy leads to a downward bias in the regression slope coefficient. For this reason, it is likely that the true slope is even higher, for the occasions on which agents borrowed rather than lent sterling are only crudely identified.

Lastly, it remains to contrast the speculative activity in the fall, when agents were purchasing sterling bills, with behaviour in the rest of the year. Combining the September – November with the December –May data, allowing for a transaction costs dummy for the September- November months gives:

$$s_{t+60} - s_t = 0.0001 + \quad 0.47[n(r_t^{US} - r_t^{UK})] - 0.0009\,Fall + v_{t+60} \qquad R^2 = 0.12$$
$$(0.0004) \quad (0.13)^{**} \qquad (0.0006) \qquad n = 252 \tag{18}$$

Similarly, combining the September – November with the July – August data, allowing for a transaction costs dummy for the September- November months gives:

$$s_{t+60} - s_t = -0.003 + \quad 0.50[n(r_t^{US} - r_t^{UK})] + 0.00245 Fall + v_{t+60} \qquad R^2 = 0.30$$
$$(0.0004)^{**} \quad (0.17)^{**} \qquad (0.0007)^{**} \qquad n = 148 \tag{19}$$

These two regressions provide evidence of the transactions costs wedge between summer, when agents were borrowing sterling, and fall, when they were buying sterling. The coefficient is a little smaller than the previous estimates, but still equivalent to 1.4% annualized and thus close to the value in the contemporaneous literature. In contrast, there is no evidence of a difference between the fall months and the "ordinary" months from December to May. This may suggest that there was relatively little speculative borrowing between December and May, even though the price of sterling bills regularly reached its peak during this time.

6. Uncovered interest parity, 1888 – 1896

Hallwood, McDonald, and Marsh (2000) argue that there is strong evidence that the U.S. dollar suffered a peso problem prior to November 1896. They estimated a model estimating

financial market's expectations of the probability that the U.S. Government would devalue the dollar. In this section I examine the effect of the peso problem on the estimates on the uncovered interest parity regressions.

6.1. The silver question.

When the United States resumed convertibility in 1879, an ounce of pure gold was worth $20.67. However, it was uncertain whether the U.S. would remain on the gold standard at this rate[9]. The Treasury was required to convert $2 million worth of silver into silver dollars each month, coins that could be exchanged for silver certificates that were legal tender and good for all public dues. By the late 1880s there was concern that the Treasury could be forced off the gold standard because it had much smaller gold reserves than there were notes on issue. These concerns were exacerbated by the July 1890 Sherman Act, which required the Treasury to purchase 4,500,000 ounces of silver each month, at a cost of approximately $50 million per year. Payment was made with Treasury notes that were redeemable in gold or silver at the discretion of the Secretary of the Treasury. The Sherman Act therefore rapidly increased the note issue redeemable for gold, without increasing the Government's supply of gold, and generated fears that the U.S. Treasury would be forced onto a silver standard.

Immediately after the Sherman Act was passed, gold redemption began by both U.S. and foreign agents. There were net gold exports of $87 million in the twelve months to June 1893, and the government's gold reserves fell to $100 million by April 1893, ultimately sparking the 1893 financial crisis[10]. While the Sherman Act was repealed in August 1893, the 1896 election was fought over the silver question, and there were large gold exports in the run up to the election. Indeed, it was not until McKinley won the election in November that silver speculation ended. Certainty that the U.S would not change the mint parity rate and thus devalue the dollar was reflected in an immediate decline in U.S. interest rates relative to British rates.

This episode is a classic example of the peso problem. Since the expected devaluation never occurred, there is a substantial difference between the distribution of the expected exchange rate change and the distribution of the actual exchange rate change. The effect of the peso problem is strikingly evident in the graphs of the data for the pre-and post 1896 periods, for both the shipment dates and the non-shipment dates (see figures 6 and 7). In the earlier period there is a large cluster of points in the lower right corner of the graph, where a high U.S.

[9] See the discussion in Lauck (1907) Chapter 2.

[10] This was a critical level, for the Treasury could not issue gold certificates in exchange for gold when the reserve was less than $100 million.

interest rate differential is followed by a subsequent decrease in the exchange rate. In Figure 6, these are occasions when gold was exported to London despite high U.S. interest rates and the threat of a decline in sterling if the dollar were not devalued. In Figure 7, there are occasions when sterling was above the mint parity rate and agents would not sell sterling to purchase dollars despite high U.S. interest rates and the likelihood of an exchange rate decline if the dollar were not devalued.

6.2. Data and estimation.

The uncovered interest parity regressions are estimated separately for the gold shipment dates and the non-shipment dates. The gold-shipment date regression includes a dummy variable to separate for exports and imports.

6.2.1. Gold shipment dates 1888-1896

$$\begin{array}{lll} s_{t+n} - s_t = 0.0029 - 0.0055\, Gold\ Export - 0.10[n(r_t^{US} - r_t^{uk})] + e_{t+n} & R^2 = 0.32 & \\ \quad (0.0014)\ (0.0014) \qquad\qquad (0.153) & n = 102 & \end{array} \tag{20}$$

The dummy coefficient is negative and equivalent to sterling depreciating at an annual rate of 3.3%. This coefficient is substantially more negative than in the post 1897 period.

6.2.2. No shipment dates 1888-1896

$$\begin{array}{ll} s_{t+n} - s_t = 0.0014 - 0.33[n(r_t^{US} - r_t^{uk})] + e_{t+n} & R^2 = 0.04 \\ \quad (0.00048)\ (0.165) & n = 321 \end{array} \tag{21}$$

The spot estimates are 0.60 and 0.67 below the estimates for the corresponding equations in the post-1896 period. The contrast between the positive and negative slope coefficients of the "No-shipment" date regressions in the two periods is striking. When the price of sterling was high after the 1896 election, an increase in U.S. interest rates made dollar assets more attractive to speculators, who responded by issuing more long sterling bills to purchase dollars. Sterling prices fell. Prior to the election, however, a rise in U.S. interest rates typically reflected fears of a devaluation of the dollar and speculators purchased sterling, increasing its price. As devaluation fears increased, spot rates for sterling were bid up, leading to a greater subsequent sterling depreciation, and higher and higher U.S. interest rates were needed to entice people to hold dollars. In Figure 6 these occasions are the large number of points where U.S. interest rates were much higher than U.K. interest rates but for which there was a large subsequent depreciation of sterling.

Using different methodology, Flood and Rose (1996) argued there was evidence of the peso problem in their examination of uncovered interest parity in the European monetary system. These results are qualitatively similar to those presented by Flood and Rose. This provides additional empirical evidence that estimates of the uncovered parity regression are biased during periods when there are unrealized expectations of a devaluation.

7. Conclusions

This paper investigates the conditions under which agents undertook currency speculation using short dated instruments during the Gold Standard era. This era is interesting to examine not only because the historic record suggests that there was frequent currency speculation, but also because the structure of the market allows the identification of times when speculation did and did not occur. While the market structure has no contemporary equivalents, the findings provide several lessons about the nature of currency speculation that potentially have general relevance.

Six results stand out. First, in part because transactions costs in the market were so high, speculators were selective about when they took positions in the market. It is possible to show that the exchange rate was not determined by intertemporal currency speculation on twenty percent of weeks – these are the occasions when gold was shipped across the Atlantic – and it is plausible there were many more occasions when speculation was unimportant, particularly as it appears that the high transactions cost deterred agents from borrowing sterling to invest in dollars, except in summer. These days, the transactions costs of taking speculative positions in currency markets are much smaller, so it is unlikely that transaction cost issues are important. Nonetheless, the general issue, that speculators are selective when they take positions in currency markets, is relevant. For example, Sarno, Valente, and Leon (2006) argue that currency speculation only takes place when the reward/risk ratio exceeds a certain threshold. Conceptually, this is a very similar argument to that made here, that currency speculation only took place once the expected returns exceeded the transactions costs. Consequently, developing techniques to identify the circumstances when speculation does and does not occur remains a priority. In the absence of clear identification strategies, indirect method such as threshold regressions may be necessary.

Secondly, the gold shipment data provide some insight into the extent to which risk premiums vary over time. In particular, during the fall the potential returns from buying sterling bills were on average 1 percent per annum higher on the occasions that speculators did not buy bills but gold was imported than on the occasions that speculators did buy bills. This suggests

that relatively small changes in the risk premium – of the order of 1 percent per annum - were enough to deter speculators from holding sterling bills.

Thirdly, the evidence suggests that speculation mainly took place to take advantage of exchange rate movements rather than interest rate differentials. During this period, agents mainly issued sterling bills in summer, to take advantage of the expected seasonal decline in sterling during the fall, and frequently purchased bills in fall in anticipation that the price of sterling bills would increase once the flood of cotton and grain trade bills receded. When agents borrowed sterling bills in the summer, it was often when sterling interest rates were relatively high compared to U.S. interest rates, while when they purchased sterling in the fall it was often when sterling interest rates were lower than U.S. dollar interest rates. The pre-1897 data provide further evidence on the importance of exchange rate expectations rather than interest rate differentials, as it is clear that agents purchased sterling despite high U.S. interest rates because of expectations that the U.S. dollar would be devalued.

Fourthly, the evidence suggest that even when agents undertook uncovered interest rate speculation, profitability varied systematically with the interest rate differential – that is, the estimated slope of the uncovered interest parity regression was less than 1. Indeed, in this period, the slope was approximately 0.5. If speculators were buying sterling bills, a one percentage point increase in the dollar-sterling interest rate differential was associated with an additional subsequent half percentage point increase in the price of sterling bills – and thus the profitability of purchasing sterling bills was lower, the higher the interest rate differential. Conversely, if speculators were borrowing sterling, the profitability of issuing sterling bills was higher, the higher the dollar-sterling interest rate differential, as a one percentage point increase in the interest rate differential was also associated with an additional subsequent half percentage point increase in the price of sterling bills. Consequently, it appears that not only were agents selective as to when they undertook speculative positions in the foreign exchange market, but they accepted levels of profit that varied systematically with the interest rate differential.

Fifthly, this paper confirms the Flood and Rose (1996) result that the uncovered interest rate parity hypothesis holds much better in fixed exchange rate regimes than flexible exchange rate regimes. Flood and Rose (1996) used data from the European Monetary System, 1979 – 1994 to establish their result, finding that the slope of the uncovered interest parity regression was approximately 0.7. This paper suggests that the slope of the uncovered interest parity lines was approximately 0.5 during the gold standard era. Using a different technique, this paper also confirms their result that the peso problem causes the slope of an uncovered interest rate parity regression to decline by approximately 0.7.

Finally, the paper enhances our understanding of the operation of the gold standard exchange rate mechanism. While there was active financial speculation to absorb fluctuations in the supply of trade bills, this speculation was limited by the willingness of agents to borrow one currency and invest in the other. On the occasions that no further agents could be induced to borrow and invest, the price of sterling would reach the gold point and gold would be shipped across the Atlantic. Although these shipments were relatively frequent — on some twenty percent of weeks arbitrage operations took place — this paper confirms Goodhart's insight that financial speculation was sufficiently developed that gold shipments were a secondary means of absorbing the seasonal fluctuations in the current account.

Bibliography

Andrew, A. Piat (1910a) *National Monetary Commission: Statistics for the United States, 1867-1909*. Senate Document Number 570, (61st Congress, 2nd session.) (Washington, D.C.: Government Printing Office)

Andrew, A. Piat (1910b) *National Monetary Commission: Statistics for Great Britain, Germany, and France, 1867-1909*. Senate Document Number 578, (61st Congress, 2nd session.) (Washington, D.C.: Government Printing Office)

Coleman, A.M.G. 2007, "The pitfalls of estimating transactions costs from price data: evidence from trans-Atlantic gold-point arbitrage, 1886 – 1905," *Explorations in Economic History* 44(3), 387-410.

The Commercial and Financial Chronicle (New York: W. B. Dana Corp, 1884 - 1906)

The Economist London: 1885 - 1906.

Engel, Charles (1996) "The forward discount anomaly and the risk premium: a survey of recent evidence." *Journal of Empirical Finance* 3 123-192.

Escher, Franklin (1913) *Elements of Foreign Exchange (3rd Edition)* (New York: The Bankers Publishing Company)

Fama, Eugene F. (1984) "Forward and spot exchange rates" Journal of Monetary Economics 14(3) 319-338.

Flood, Robert P. and Andrew K. Rose (1996) "Fixes: Of the Forward Discount Puzzle" *Review of Economics and Statistics* 78 (4) 748-752

Foster, Ellen L. (1994) *Seasonal Movements of Exchange rates and Interest rates under the pre-World War I Gold Standard.* (New York and London: Garland Publishing, Inc.)

Goodhart, C.A.E. (1969) *The New York Money Market and the Finance of Trade, 1900-1913.* (Cambridge: Harvard University Press)

Hallwood, C. Paul, Ronald McDonald, and Ian Marsh (2000) "Realignment expectations and the US dollar, 1890-1897: was there a 'Peso Problem'," *Journal of Monetary Economics* 46 605-620

Kemmerer, Edwin W. (1910) *Seasonal Variations in Demands for Currency and Capital.* (Washington: Government Printing Office)

Lauck, W. Jett (1907) *The Causes of the Panic of 1893* (Boston and New York: Houghton, Mifflin and Company)

Margraff, Anthony W. (1904) *International Exchange (2nd Edition)* (Chicago: Geo. E. Marshall & Co.)

New York Times. New York: 1884 - 1906.

Newey, Whitney K., and Kenneth D. West (1987) "A simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix." *Econometrica* 55 (3) 703-708

Officer, L.H. (1996) *Between the Dollar-Sterling Gold Points: Exchange Rates, Parity, and Market Behavior.* (Cambridge: Cambridge University Press)

Sarno, Lucio, Giorgio Valente, and Hyginus Leon (2006) "Nonlinearity in deviations from uncovered interest parity: an explanation of the forward bias puzzle", *Review of Finance* 10(3) 443-482.

Sayers, R.S (1936) *Bank of England Operations 1890 – 1914* (London: P.S. King and Son Ltd)

Whitaker, Albert C (1920) *Foreign Exchange* (New York and London: D. Appleton and Company)

York, Thomas (1923) *International Exchange: Normal and Abnormal* (New York: The Ronald Press Company)

Figure 1: Interest rate differential (r_{us}-r_{uk}), 1888-1905

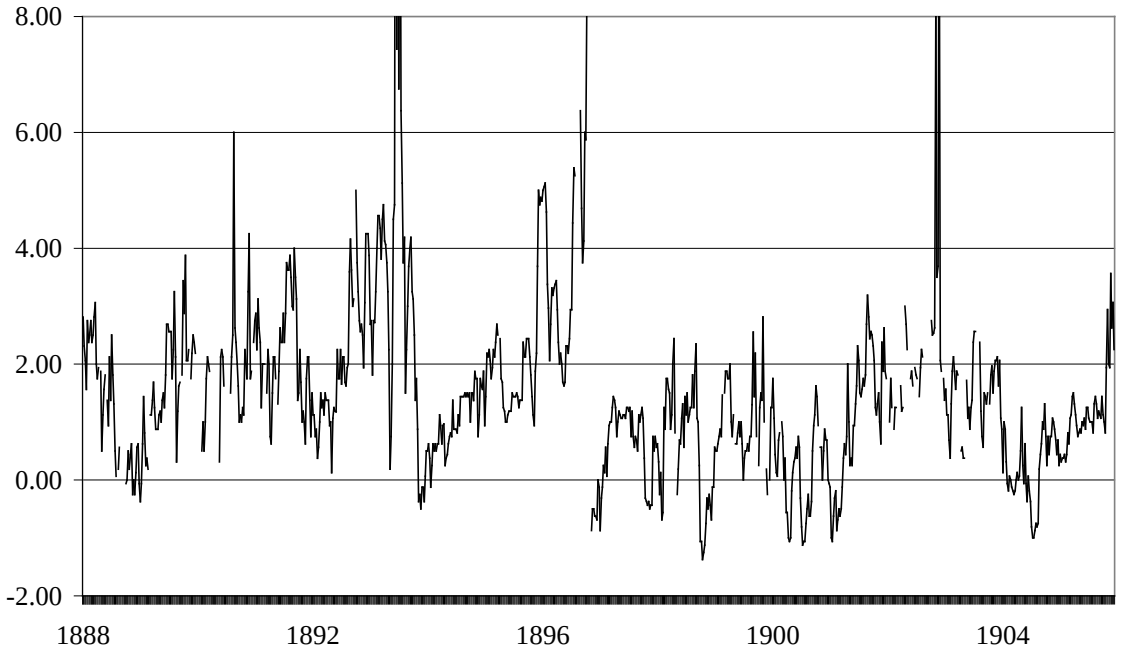


Figure 2: Schematic diagram of the sterling bill market dollar when gold is traded

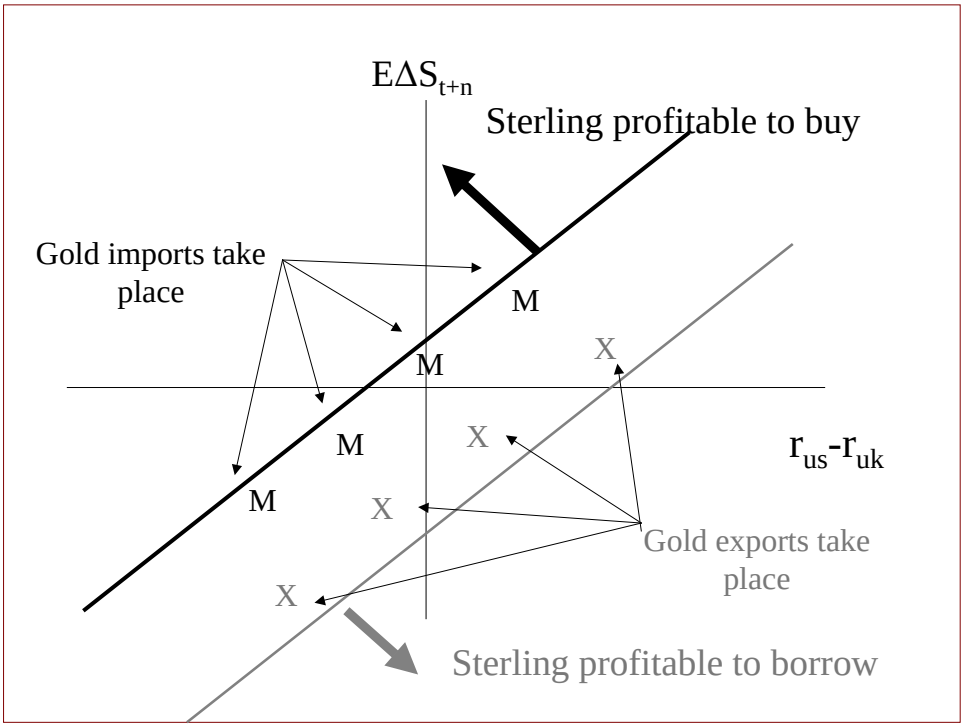


Figure 3: Change in spot rate versus interest differential, all dates, 1897-1905

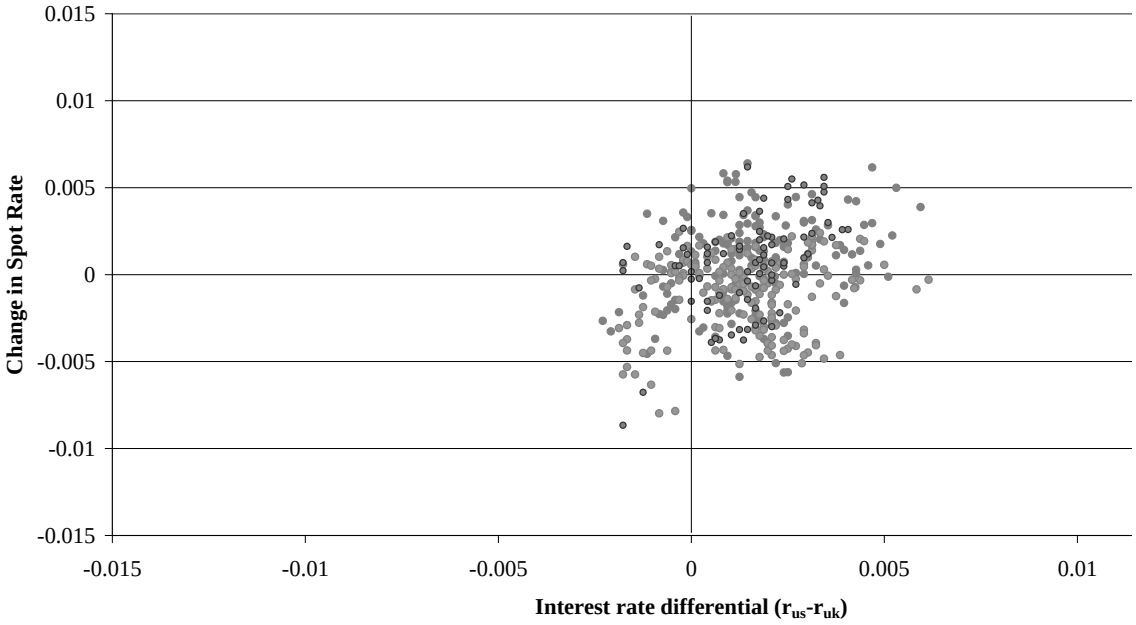


Figure 4: Change in spot rate versus interest differential, gold shipment dates, 1897-1905

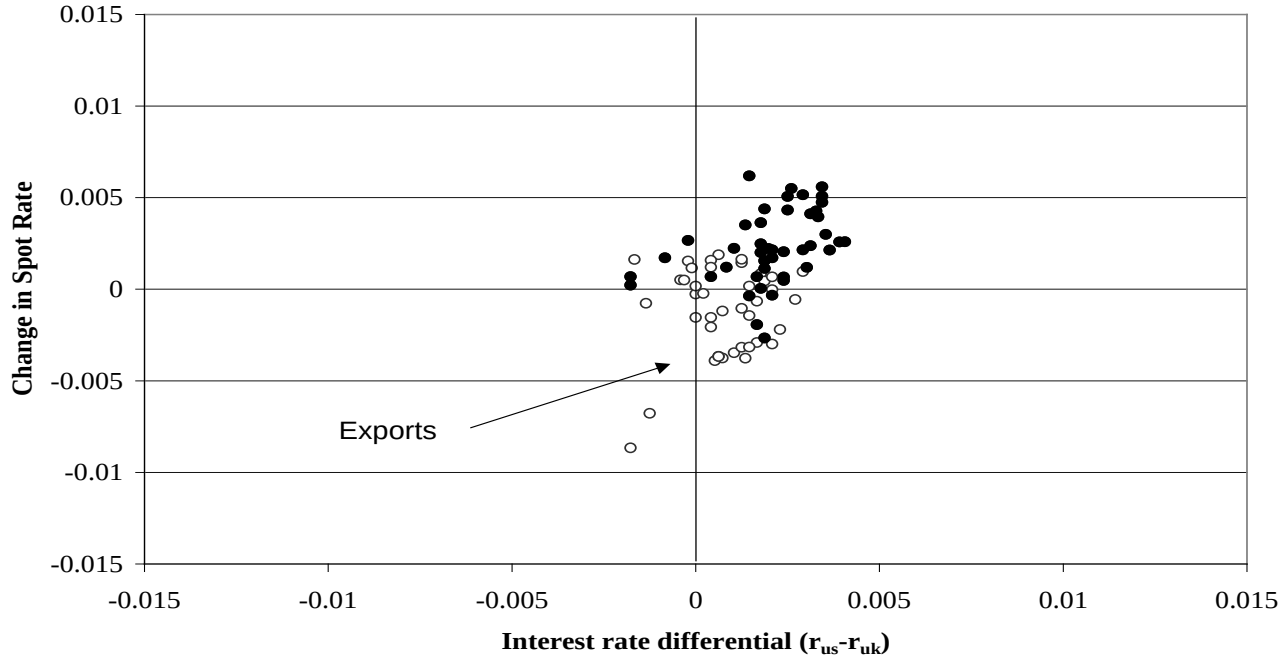


Figure 5: Potential returns from buying sterling bills, September – November 1897-1905

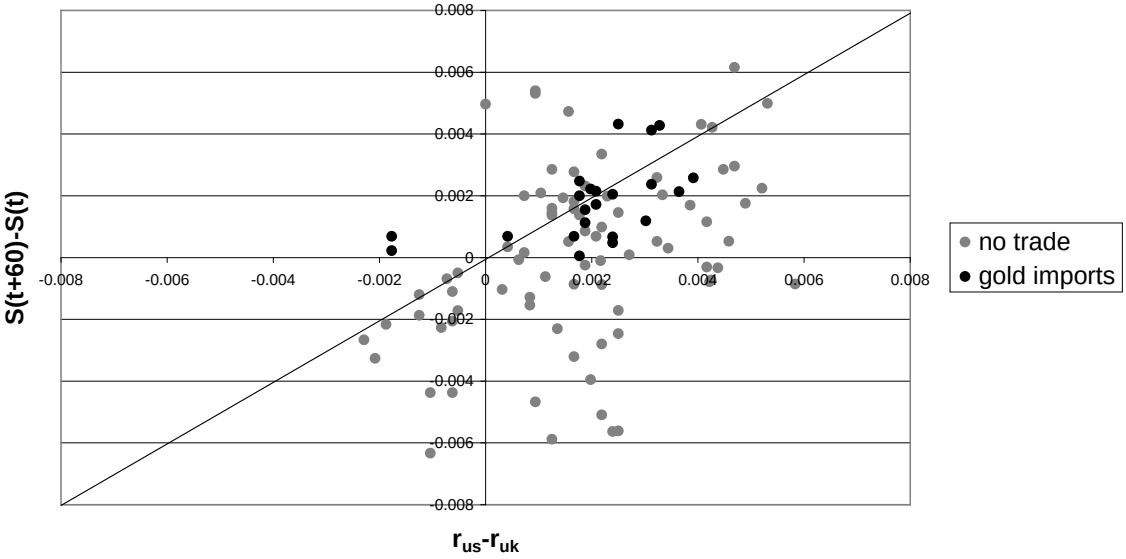


Figure 6: Change in spot rate versus interest rate differential, gold shipment dates, 1888-1896

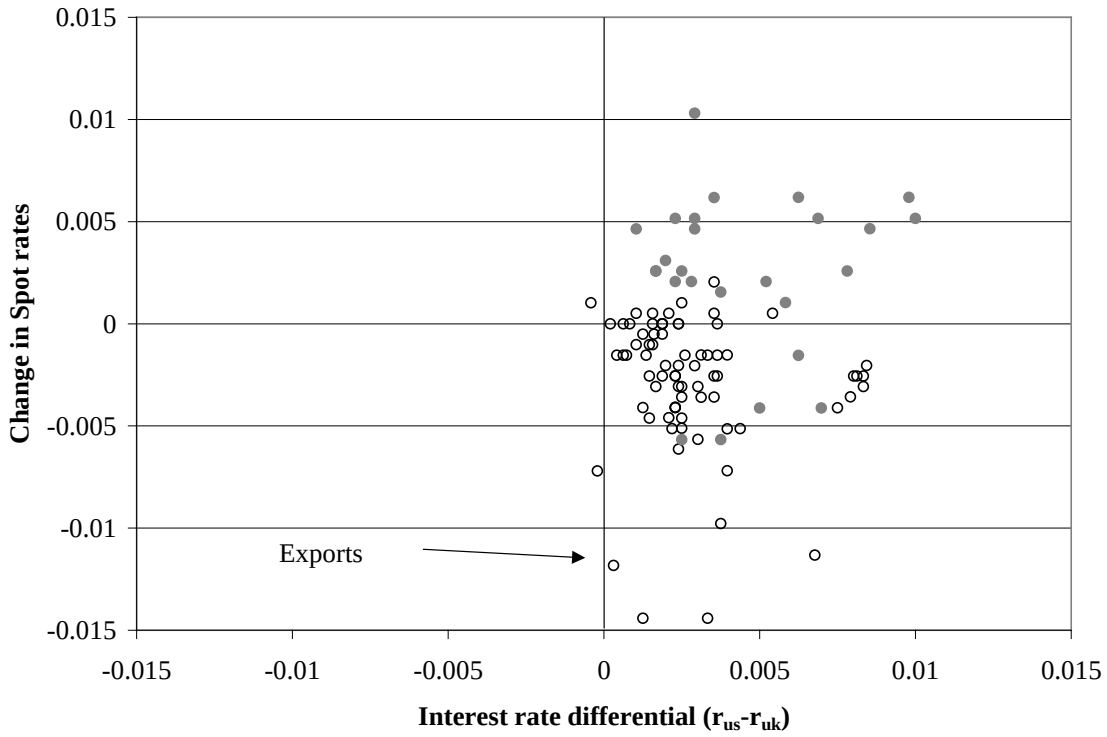
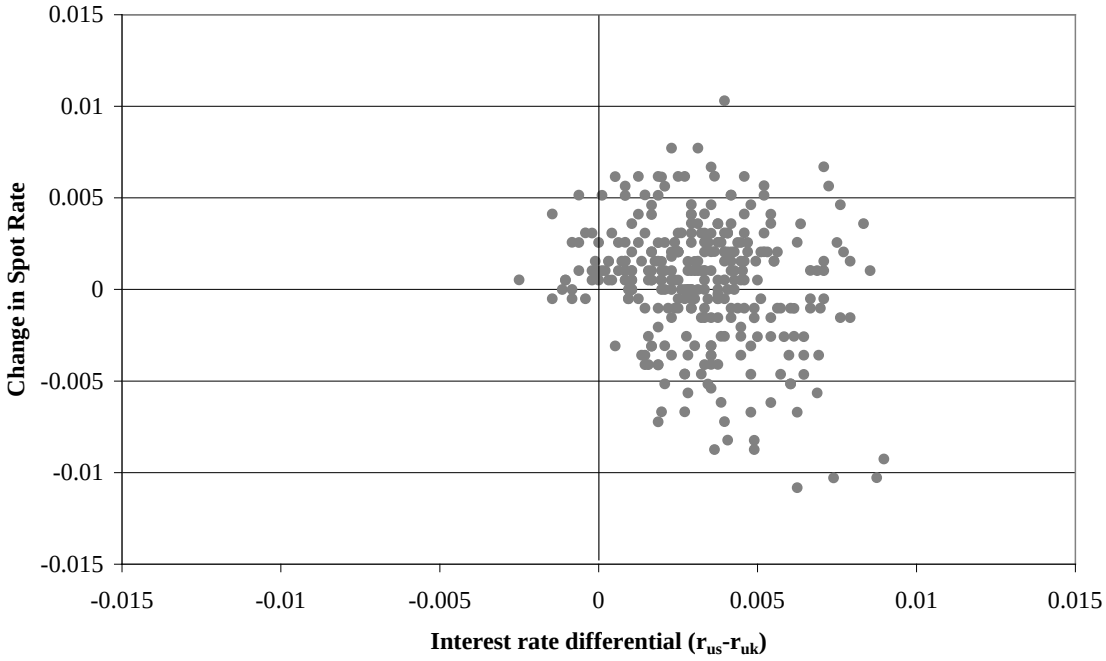


Figure 7: Change in spot rate versus interest rate differential, no-shipment dates, 1888-1896.



Motu Working Paper Series

All papers are available online at www.motu.org.nz or by contacting Motu Economic and Public Policy Research.

10-01 Coleman, Andrew. 2010. "Squeezed in and squeezed out: the effects of population ageing on the demand for housing".

09-17 Todd, Maribeth and Suzi Kerr. 2009. "How Does Changing Land Cover and Land Use in New Zealand relate to Land Use Capability and Slope?"

09-16 Kerr, Suzi and Wei Zhang. 2009. "Allocation of New Zealand Units within Agriculture in the New Zealand Emissions Trading System".

09-15 Grimes, Arthur; Cleo Ren and Philip Stevens. 2009. "The Need for Speed: Impacts of Internet Connectivity on Firm Productivity".

09-14 Coleman, Andrew and Arthur Grimes. 2009. "Fiscal, Distributional and Efficiency Impacts of Land and Property Taxes".

09-13 Coleman, Andrew. 2009. "The Long Term Effects of Capital Gains Taxes in New Zealand".

09-12 Grimes, Arthur and Chris Young. 2009. "Spatial Effects of 'Mill' Closure: Does Distance Matter?"

09-11 Maré, David C and Steven Stillman. 2009. "The Impact of Immigration on the Labour Market Outcomes of New Zealanders".

09-10 Stillman, Steven and David C Maré. 2009. "The Labour Market Adjustment of Immigrants in New Zealand".

09-09 Kerr, Suzi and Kelly Lock. 2009. "Nutrient Trading in Lake Rotorua: Cost Sharing and Allowance Allocation".

09-08 Coleman, Andrew and Grant M Scobie. 2009. "A Simple Model of Housing Rental and Ownership with Policy Simulations".

09-07 Crawford, Ron. 2009. "Variations in Earnings Growth: Evidence from Earnings Transitions in the NZ Linked Income Survey".

09-06 Maré, David C. 2009. "Agglomeration Elasticities in New Zealand".

09-05 Poot, Jacques. 2009. "Trans-Tasman Migration, Transnationalism and Economic Development in Australasia".

09-04 Hengyun, Ma; Les Oxley and John Gibson. 2009. "China's Energy Situation and Its Implications in the New Millenium".

09-03 Hengyun, Ma; Les Oxley and John Gibson. 2009. "Testing for Energy Market Integration in China".

09-02 Hengyun, Ma; Les Oxley, John Gibson and Bongguen Kim. 2009. "China's Energy Economy: Technical Change, Factor Demand and Interfactor/Interfuel Substitution".

09-01 Cumming, Jackie; Steven Stillman and Michelle Poland. 2009. "Who Pays What for Primary Health Care? Patterns and Determinants of the Fees Paid by Patients in a Mixed Public-Private Financing Model".

08-14 Coleman, Andrew. 2008. “Tax, Credit Constraints, and the Big Costs of Small Inflation”.

08-13 Coleman, Andrew. 2008. “Storage Under Backwardation: A Direct Test of the Wright-Williams Conjecture”.

08-12 Maré, David C. 2008. “Labour Productivity in Auckland Firms”.

08-11 Stillman, Steven; Malathi Velamuri and Andrew Aitken. 2008. “The Long-Run Impact of New Zealand's Structural Reform on Local Communities”.

08-10 Grimes, Arthur and Andrew Aitken. 2008. “Water, Water Somewhere: The Value of Water in a Drought-Prone Farming Region”.

08-09 Coleman, Andrew. 2008. “Inflation and the Measurement of Saving and Housing Affordability”.

08-08 Coleman, Andrew and Özer Karagedikli. 2008. “The Relative Size of New Zealand Exchange Rate and Interest Rate Responses to News”.

08-07 Grimes, Arthur and Yun Liang. 2008. “Bridge to Somewhere: The Value of Auckland's Northern Motorway Extensions".

08-06 Stillman, Steven and David C Maré. 2008. “Housing Markets and Migration: Evidence from New Zealand”.

08-05 Lock, Kelly and Suzi Kerr. 2008. “Nutrient Trading in Lake Rotorua: Choosing the Scope of a Nutrient Trading System”.

08-04 Kerr, Suzi and Andrew Sweet. 2008. “Inclusion of Agriculture and Forestry in a Domestic Emissions Trading Scheme: New Zealand’s Experience to Date”.

08-03 Kerr, Suzi and Kit Rutherford. 2008. “Nutrient Trading in Lake Rotorua: Reporting and Modelling Net Nutrient Inputs”.

08-02 Lock, Kelly and Suzi Kerr. 2008. “Nutrient Trading in Lake Rotorua: Overview of a Prototype System”.

08-01 Stroombergen, Adolf. 2008. “ESSAM General Equilibrium Model: Estimation of 2005/06 Input-Output Tables”.

07-13 Hall, Viv and John McDermott. 2007. "A quarterly post-World War II real GDP series for New Zealand".

07-12 Gibson, John; Trinh Le and Steven Stillman. 2007. "What Explains the Wealth Gap Between Immigrants and the New Zealand Born?"

07-11 Maré, David C.; Melanie Morten and Steven Stillman, 2007. “Settlement Patterns and the Geographic Mobility of Recent Migrants to New Zealand”.

07-10 Grimes, Arthur; David C. Maré and Melanie Morten, 2007. “Adjustment in Local Labour and Housing Markets.”

07-09 Grimes, Arthur and Yun Liang, “Spatial Determinants of Land Prices in Auckland: Does the Metropolitan Urban Limit Have an Effect?”

07-08 Kerr, Suzi; Kit Rutherford and Kelly Lock, “Nutrient Trading in Lake Rotorua: Goals and Trading Caps”.

07-07 Hendy, Joanna; Suzi Kerr and Troy Baisden, “The Land Use in Rural New Zealand Model Version 1 (LURNZ v1): Model Description”.

07-06 Lock, Kelly and Suzi Kerr, “Nutrient Trading in Lake Rotorua: Where Are We Now?”

07-05 Stillman, Steven and David C Maré, "The Impact of Immigration on the Geographic Mobility of New Zealanders".

07-04 Grimes, Arthur and Yun Liang, "An Auckland Land Value Annual Database".

07-03 Kerr, Suzi; Glen Lauder and David Fairman, "Towards Design for a Nutrient Trading Programme to Improve Water Quality in Lake Rotorua".

07-02 Lock, Kelly and Stefan Leslie, "New Zealand's Quota Management System: A History of the First 20 Years".

07-01 Grimes, Arthur and Andrew Aitken. 2007. "House Prices and Rents: Socio-Economic Impacts and Prospects".

06-09 Maani, Sholeh A.; Rhema Vaithianathan and Barbara Wolf. 2006. "Inequality and Health: Is House Crowding the Link?"

06-08 Maré, David C and Jason Timmins. 2006. "Geographic Concentration and Firm Productivity".

06-07 Grimes, Arthur; David C Maré and Melanie Morten. 2006. "Defining Areas Linking Geographic Data in New Zealand".

06-06 Maré, David C and Yun Liang. 2006. "Labour Market Outcomes for Young Graduates".

06-05 Hendy, Joanna and Suzi Kerr. 2006. "Land-Use Intensity Module: Land Use in Rural New Zealand Version 1".

06-04 Hendy, Joanna; Suzi Kerr and Troy Baisden. 2006. "Greenhouse Gas Emissions Charges and Credits on Agricultural Land: What Can a Model Tell Us?"

06-03 Hall, Viv B; John McDermott and James Tremewan. 2006. "The Ups and Downs of New Zealand House Prices".

06-02 McKenzie, David; John Gibson and Steven Stillman. 2006. "How Important is Selection? Experimental vs Non-Experimental Measures of the Income Gains from Migration".

06-01 Grimes, Arthur and Andrew Aitken. 2006. "Housing Supply and Price Adjustment".

05-14 Timmins, Jason. 2005. "Is Infrastructure Productive? Evaluating the Effects of Specific Infrastructure Projects on Firm Productivity within New Zealand".

05-13 Coleman, Andrew; Sylvia Dixon and David C Maré, "Māori Economic Development—Glimpses from Statistical Sources".

05-12 Maré, David C 2005. "Concentration, Specialisation and Agglomeration of Firms in New Zealand".

05-11 Holmes, Mark J and Arthur Grimes. 2005. "Is There Long-Run Convergence of Regional House Prices in the UK?"

05-10 Hendy, Joanna and Suzi Kerr. 2005. "Greenhouse Gas Emission Factor Module: Land Use in Rural New Zealand—Climate Version 1".

05-09 Poland, Michelle and David C Maré. 2005. "Defining Geographic Communities".

05-08 Kerr, Suzi; Joanna Hendy, Emma Brunton and Isabelle Sin. 2005. "The Likely Regional Impacts of an Agricultural Emissions Policy in New Zealand: Preliminary Analysis".

05-07 Stillman, Steven. 2005. "Examining Changes in the Value of Rural Land in New Zealand between 1989 and 2003".

05-06 Dixon, Sylvia and David C Maré. 2005. "Changes in the Māori Income Distribution: Evidence from the Population Census".

05-05 Sin, Isabelle and Steven Stillman. 2005. "The Geographical Mobility of Māori in New Zealand".

05-04 Grimes, Arthur. 2005. "Regional and Industry Cycles in Australasia: Implications for a Common Currency".

05-03 Grimes, Arthur. 2005. "Intra and Inter-Regional Industry Shocks: A New Metric with an Application to Australasian Currency Union".

05-02 Grimes, Arthur; Robert Sourell and Andrew Aitken. 2005. “Regional Variation in Rental Costs for Larger Households”.

05-01 Maré, David C. 2005. “Indirect Effects of Active Labour Market Policies”.

04-12 Dixon, Sylvia and David C Maré. 2004. “Understanding Changes in Māori Incomes and Income Inequality 1997–2003”.

04-11 Grimes, Arthur. 2004. “New Zealand: A Typical Australasian Economy?”

04-10 Hall, Viv and John McDermott. 2004. “Regional Business Cycles in New Zealand: Do They Exist? What Might Drive Them?”

04-09 Grimes, Arthur; Suzi Kerr and Andrew Aitken. 2004. “Bi-Directional Impacts of Economic, Social and Environmental Changes and the New Zealand Housing Market”.

04-08 Grimes, Arthur and Andrew Aitken. 2004. “What’s the Beef with House Prices? Economic Shocks and Local Housing Markets”.

04-07 McMillan, John. 2004. “Quantifying Creative Destruction: Entrepreneurship and Productivity in New Zealand”.

04-06 Maré, David C and Isabelle Sin. 2004. “Māori Incomes: Investigating Differences Between Iwi”.

04-05 Kerr, Suzi; Emma Brunton and Ralph Chapman. 2004. “Policy to Encourage Carbon Sequestration in Plantation Forests”.

04-04 Maré, David C. 2004. “What do Endogenous Growth Models Contribute?”

04-03 Kerr, Suzi; Joanna Hendy, Shuguang Liu and Alexander S. P. Pfaff. 2004. “Uncertainty and Carbon Policy Integrity”.

04-02 Grimes, Arthur; Andrew Aitken and Suzi Kerr. 2004. “House Price Efficiency: Expectations, Sales, Symmetry”.

04-01 Kerr, Suzi; Andrew Aitken and Arthur Grimes. 2004. “Land Taxes and Revenue Needs as Communities Grow and Decline: Evidence from New Zealand”.

03-19 Maré, David C. 2003. “Ideas for Growth?”

03-18 Fabling, Richard and Arthur Grimes. 2003. “Insolvency and Economic Development: Regional Variation and Adjustment”.

03-17 Kerr, Suzi; Susana Cardenas and Joanna Hendy. 2003. “Migration and the Environment in the Galapagos: An Analysis of Economic and Policy Incentives Driving Migration, Potential Impacts from Migration Control, and Potential Policies to Reduce Migration Pressure”.

03-16 Hyslop, Dean R and David C Maré. 2003. “Understanding New Zealand’s Changing Income Distribution 1983–98: A Semiparametric Analysis”.

03-15 Kerr, Suzi. 2003. “Indigenous Forests and Forest Sink Policy in New Zealand”.

03-14 Hall, Viv and Angela Huang. 2003. “Would Adopting the US Dollar Have Led to Improved Inflation, Output and Trade Balances for New Zealand in the 1990s?”

03-13 Ballantyne, Suzie; Simon Chapple, David C Maré and Jason Timmins. 2003. “Movement into and out of Child Poverty in New Zealand: Results from the Linked Income Supplement”.

03-12 Kerr, Suzi. 2003. “Efficient Contracts for Carbon Credits from Reforestation Projects”.

03-11 Lattimore, Ralph. 2003. “Long Run Trends in New Zealand Industry Assistance”.

03-10 Grimes, Arthur. 2003. “Economic Growth and the Size & Structure of Government: Implications for New Zealand”.

03-09 Grimes, Arthur; Suzi Kerr and Andrew Aitken. 2003. “Housing and Economic Adjustment”.

03-07 Maré, David C and Jason Timmins, “Moving to Jobs”.

03-06 Kerr, Suzi; Shuguang Liu, Alexander S. P. Pfaff and R. Flint Hughes. 2003. “Carbon Dynamics and Land-Use Choices: Building a Regional-Scale Multidisciplinary Model”.

03-05 Kerr, Suzi. 2003. “Motu, Excellence in Economic Research and the Challenges of ‘Human Dimensions’ Research”.

03-04 Kerr, Suzi and Catherine Leining. 2003. “Joint Implementation in Climate Change Policy”.

03-03 Gibson, John. 2003. “Do Lower Expected Wage Benefits Explain Ethnic Gaps in Job-Related Training? Evidence from New Zealand”.

03-02 Kerr, Suzi; Richard G Newell and James N Sanchirico. 2003. “Evaluating the New Zealand Individual Transferable Quota Market for Fisheries Management”.

03-01 Kerr, Suzi. 2003. “Allocating Risks in a Domestic Greenhouse Gas Trading System”.