Evaluating the Impact of the Payment System Reforms

(Updated) Submission to the Reserve Bank of Australia's Payment System Board's 2007-08 Review of Payment System Reforms

Joshua S. Gans
University of Melbourne

27th August, 2007

Joshua Gans is Professor of Management (Information Economics) at the Melbourne Business School; Professorial Fellow in the Department of Economics; and Director of the Economic Theory Centre, University of Melbourne. (Background available at www.mbs.edu/jgans and at economics.com.au). The views expressed here are his own and do not reflect those of the above organisations.

1. Introduction

On 11th December, 2006, the RBA announced its review of Payment System Reforms in accordance with its undertakings to do so, 5 years from their inception. At the same time, a call was put out for submissions from interested parties in the reform process. I made an initial submission dated 19th January, 2007. **The purpose here is to re-state that submission based on updated data and updated research by Richard Hayes (26th August, 2007).**

The deliberations over the reforms and some consulting work for a major Australian bank stimulated research on my part into the workings of the credit card system. This resulted in a stream of peer-reviewed academic publications (co-authored with Stephen King, now an ACCC Commissioner) that dealt with the need for and likely impact of the reforms to both the credit and debit card industries (See Gans and King, 2001, 2003a, 2003b, 2003c). Hence, my interest in the review and the motivation for this submission. However, I will focus exclusively on the credit card reforms and their impact.

The motivation for this submission also comes from my testimony before the House of Representatives Standing Committee on Economics, Finance and Public Administration as part of its Review of the Reserve Bank & Payments System Annual Reports, 2005.[1] This submission draws on and expands my views expressed to that committee.

My conclusions are:

1. (*Impact*): Despite their dramatic nature, econometric analysis reveals that there was no similar dramatic impact of the interchange fee reforms on credit card usage and related behaviour (Hayes, 2007). Indeed, it cannot be established that there was *any* impact across a broad range of indicators.
2. (*Neutrality*): The econometric analysis is consistent with the neutrality hypothesis that stated that changes to the interchange fee will have an impact on credit card fees and merchant services charges but not on consumer payment instrument choice and usage.
3. (*Surcharging*): The impact of the elimination of prohibitions on credit and charge card surcharging may have had important impacts. Most critically, they likely supported conditions that would drive interchange neutrality. Consequently, this policy should be continued.
4. (*Regulatory Costs*): Given this, there is no case for continued careful regulation of interchange fees. **Either such regulations should be removed or at least be bound by a cap fixed forever rather than cost-based regulation or alternatively, the interchange fee should be set at**

[1] My submission to that committee is available at http://www.aph.gov.au/house/committee/efpa/rba2005/subs/sub002.pdf.

zero. Regardless of the fee, there will likely be no on-going impact on the card system, but continued regulatory deliberations impose direct costs (compliance and enforcement) as well as indirect costs (uncertainty) on market participants. The goal should be to minimise such costs.

The outline of this submission is as follows and is structured with the above three conclusions in mind. Section 2 considers the impact of the empirical impact of the reforms. Section 3 considers economic arguments for interchange fee neutrality. Section 4 looks at potential regulatory costs. A final section concludes.

2. The Impact of the Interchange Fee Reforms

The RBA has enacted a dramatic set of reforms impacting upon the credit and card charge industry. On the 1st January, 2003, surcharging was permitted on card transactions. On the 31st October, 2003, the interchange fee was capped based on a calculation of issuer costs resulting in a reduction of approximately 50 percent. On the 23rd February, 2004, the credit card schemes were opened up to more competition.

By any standard these reforms were amongst the most drastic ever to be imposed on a previously unregulated industry. It is normally the case that such large-scale reform takes place in the wake of deregulation rather than regulation. And in regulated industries, when prices are regulated, they are regulated using a 'glide path' towards what the regulator regards as efficient. In contrast, the RBA jumped straight to its desired outcomes in a series of 'big bangs.'

At the time, the expectations in the industry were that these reforms – due to their dramatic nature – would have a big impact on the industry. Normally, this would be the case. The expectations of a large impact came from both sides of the regulatory table. Those in the card industry feared large scale change whereas the regulator wanted it to achieve its policy goals. Either way, it should have had a large impact on credit card usage – something that the RBA wanted to reduce in favour of other instruments.

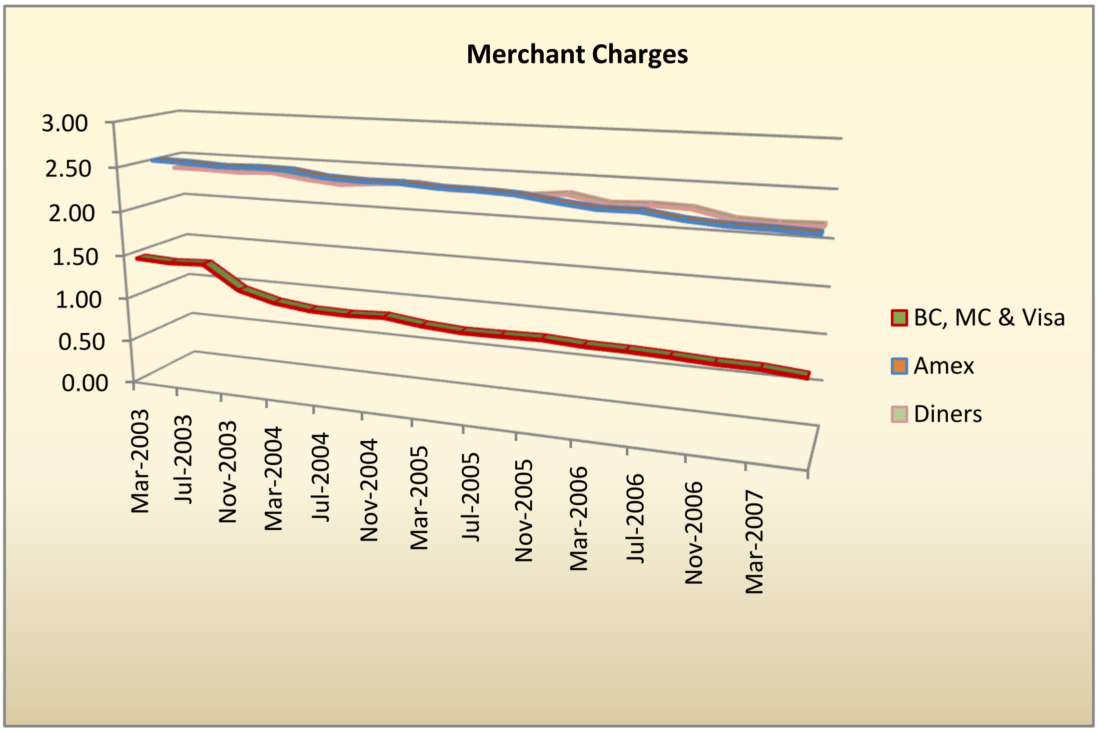
Also, the reforms extracted great interest outside of Australia. Economists around the world did not know what the impact of changing the interchange fee would be and, in many cases, were thankful to Australia for experimenting on its own economy to find out.

As I will note and explain in the next section, there was also reason to believe that, in fact, the impact of these reforms would be more limited. However, my starting point here is to consider, empirically, what the actual impact of the reforms were?

Graphical Analysis

To begin, I will plot a few time series graphs of credit card data. The purpose of this is to see whether there were any discernable breaks or changes in line with the dramatic halving of interchange fees.

First, the interchange fee change does appear to have had an impact on prices. The interchange fee is an input into merchant service charges – that merchants pay for credit card use. The following graph shows that the October 2003 reduction was associated with a corresponding reduction in the merchant service charge.



Let a denote the interchange fee and let m be the merchant service charge. The RBA/ACCC Joint Study was concerned that the acquirer margin $m - a$ was too large indicating poor competition. However, notice that there was complete pass through of the reduction in the interchange fee to the merchant service charge. Consequently, prior to and after October 2003, the acquirer margin ($m - a$) equaled about 0.4%.

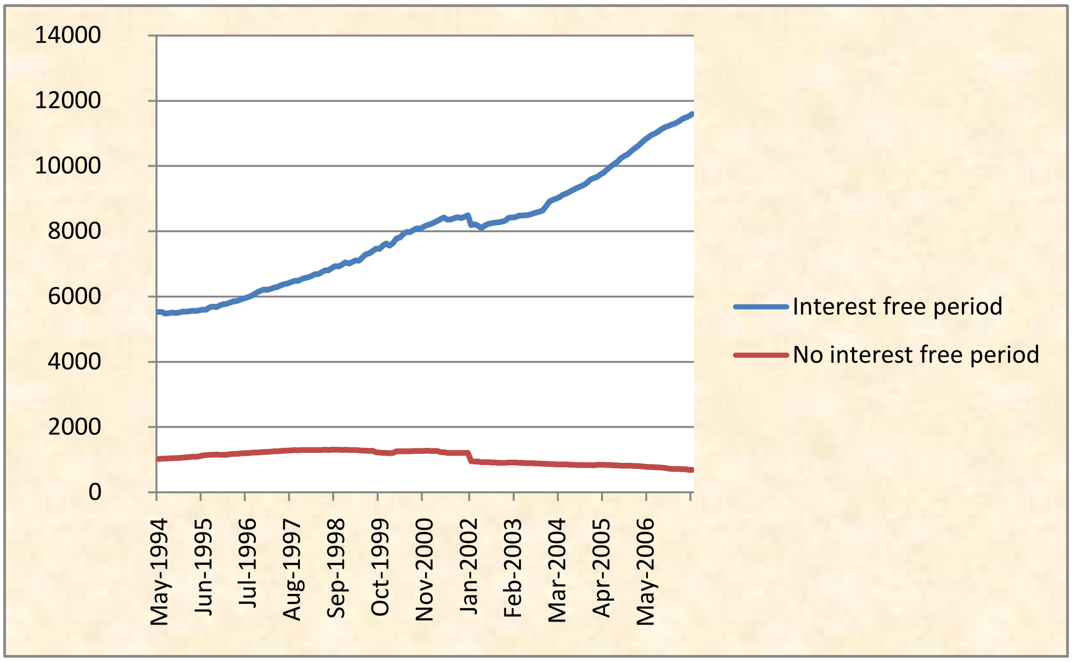
Interestingly, the common measure of the intensity of competition (specifically, the distortion from a lack of competition) – the Lerner Index – for the acquirer market actually went up. If we assume that the marginal cost of acquisition (c_A) is approximately zero, then the interchange fee represents the marginal cost facing acquirers. The Lerner index is $(m\text{-}a)/m$. It has grown from 0.32 in September 2003 to 0.42 in December 2005. Thus, the welfare distortions in acquisition have increased.

There is no corresponding available data on the issuing side of the market to consider the impacts there.

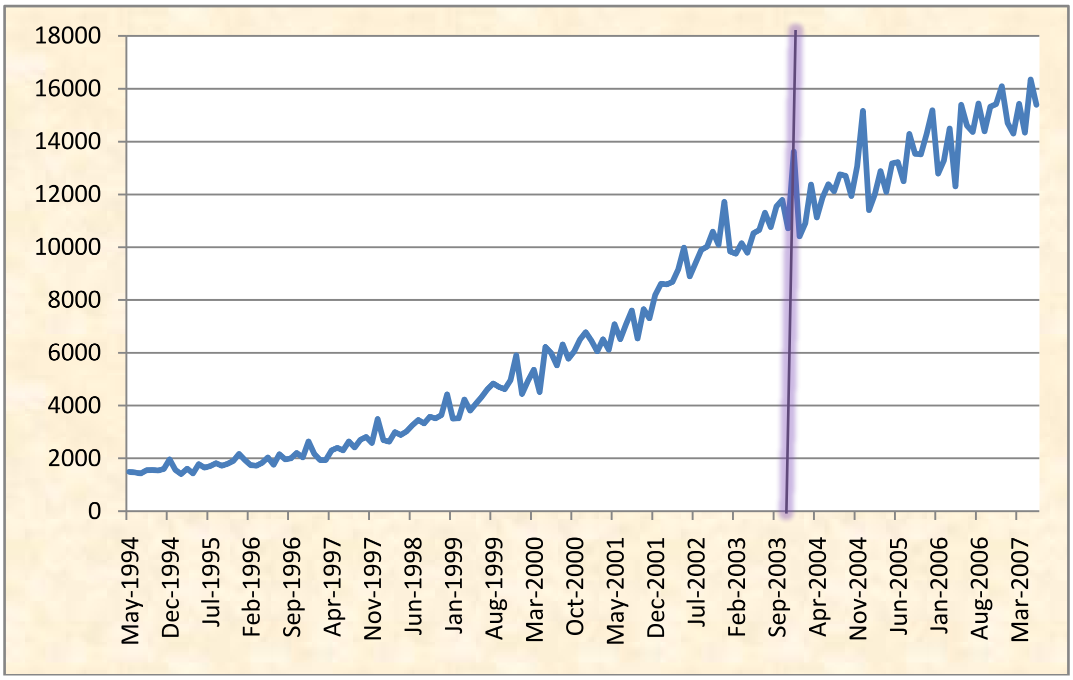
In terms of quantities, the following graphs show rises in the number of credit card accounts, the value of credit card purchases ($m) and rising credit card debt. In each case, these trends do not appear to have been impacted negatively by the reforms. Indeed, the first graph[2] indicates a jump in the number of credit card accounts. This is surprising as a reduction in the interchange fee would mean that payments to issuers would go down and hence, they would be less likely to want to issue more cards.

[2] The other break was due to a change in definition.

Number of Credit Card Accounts ('000s)[3]



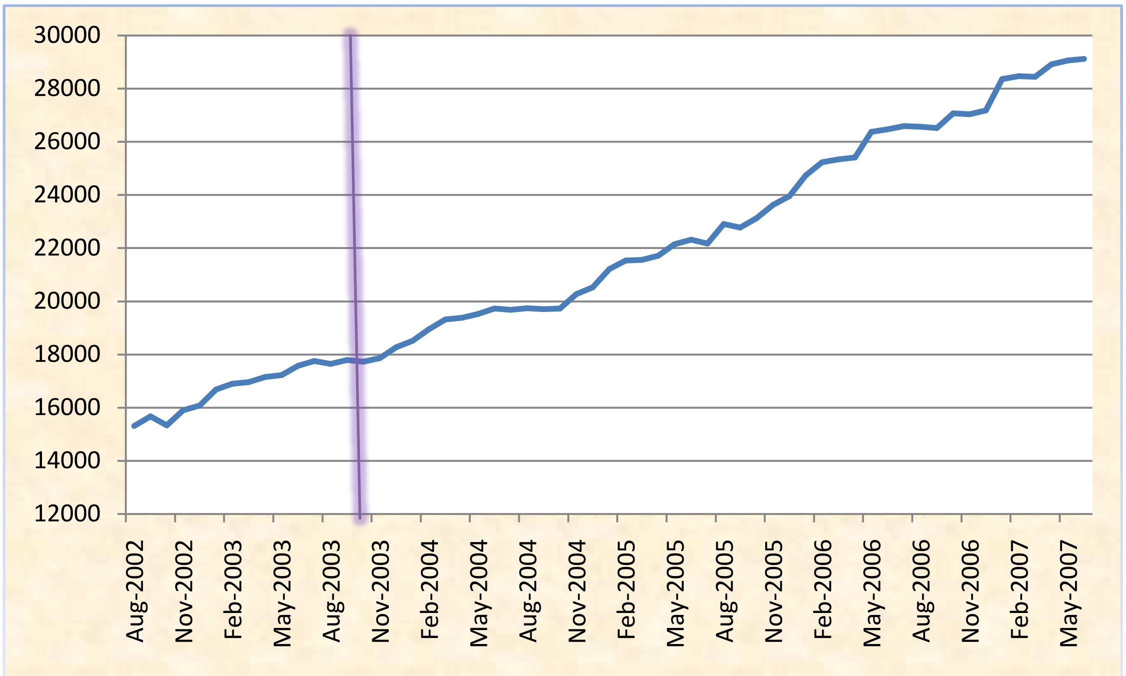
Value of Credit and Card Card Purchases ($m)



---

[3] Note the break in 2002 due to a data measurement change. This change was taken into account in Hayes (2007).

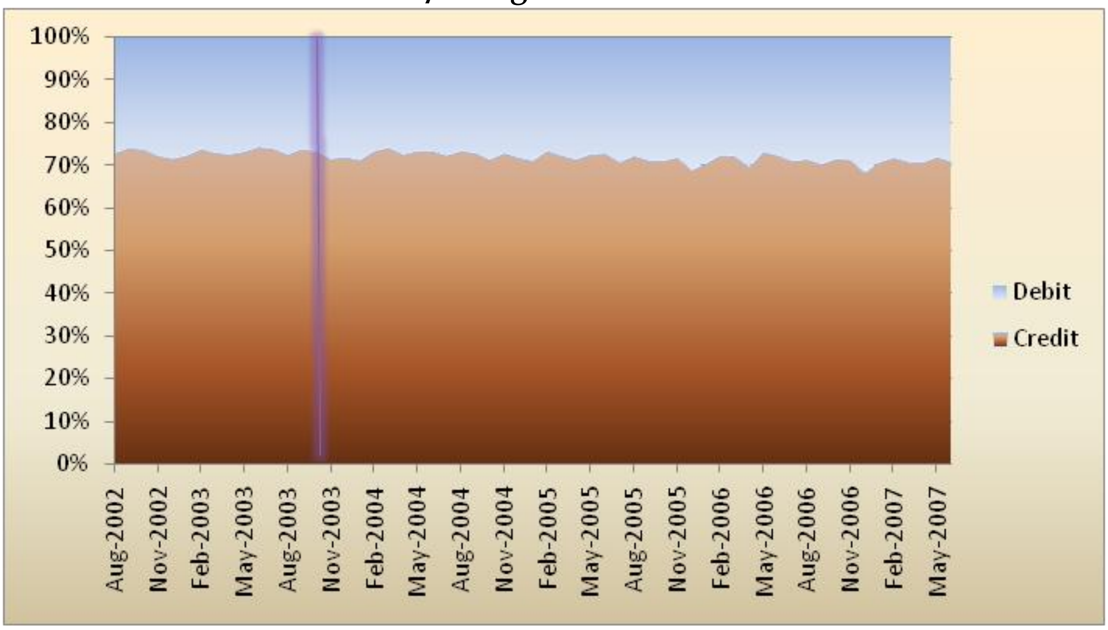
Credit and Charge Card Debt



Thus, the dramatic reforms do not appear to have hit the usage of credit cards to any great or at least significant degree. Moreover, as I report on below, this is borne out by a far more sophisticated econometric analysis.

What about the choice of payment instruments? In terms of the shares of credit and debit cards, the reforms have had no significant impact.

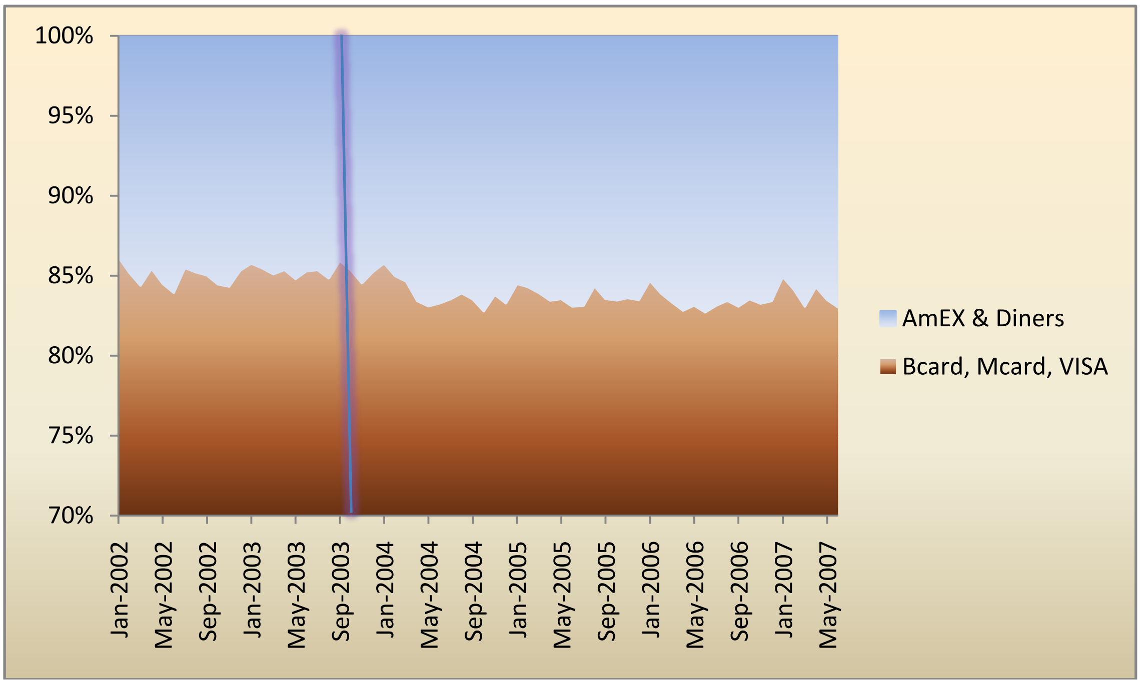
Share of Credit/Charge and Debit Transactions



There appears to be a recent drop off away from credit cards but that could easily be accounted for by seasonal or other factors. It is hard to imagine that the major impact of the reforms occurred sharply two years after the reforms.

However, when it comes to the choice between credit and charge cards (such as Amex or Diners), there has been a larger shift of a couple of percent towards charge cards. Of course, given that these types of instruments are very similar, the immediate impact of a price change would be expected to be more dramatic.

Share of Credit and Card Cards



Econometric Analysis

Graphical analysis can only get you so far in considering the impact of a change. This is because it masks other changes going on as well as time series properties of the data – most significantly, seasonality, and long-term trends that need to be taken into account. The RBA have recognised the value of econometric analysis in their work in all other policy areas. However, to date, I am not aware of any econometric analysis whose results have been disclosed publicly or alluded to in some other way that has been conducted in measuring the impact of its own payment system reforms.

There is one analysis in the literature that does do some econometrics. Chang, Evans and Garcia-Swartz (2005) conduct a similar graphical analysis to that above but also look for differences in quarterly and annual growth rates in quantity data on credit card use. They find no evidence of a significant impact from the reforms and, if anything, some positive impacts. However, their analysis does not consider the full time series properties of the data in particular seasonality issues and they also appear to aggregate credit and charge card data.

Appended to this submission is a paper by Richard Hayes (26th August, 2007) – "An Econometric Analysis of the Impact of the RBA's Credit Card Reforms" – that, for the first time, conducts a series of sensible econometric tests to consider whether the interchange fee changes had a significant impact on credit transaction values, account numbers and shares amongst payment instruments. The tests provided utilise RBA data that was public as of the writing of this submission and are otherwise the set of tests that a serious econometric analysis would undertake.

I will not describe here the precise tests carried out in the appended paper. Instead I will summarise the broad findings:

1. *Seasonality*: credit card transaction value and credit card market shares (in both the payment and card markets) were all strongly seasonal. Credit card account numbers were not seasonal although there appeared to be a December effect.
2. *Stationarity*: only the growth rate of credit card transaction volumes was stationary without considering structural breaks.
3. *Breakpoints*: given that the reforms occurred in October 2003 and that we know that there was a price impact at that point, it is natural to test for a break in the data at that date. This includes a levels break and also a growth break. The econometric tests for a break-point show that we are unable to reject the hypothesis that there was no break in October 2003 for the value of credit card transactions. There was, however, some evidence for a break in the credit card accounts series but this was positive – a step change increase in card accounts. This could be the result of an interest rate change at that time. Finally, there is no evidence of a significant break in the credit card share of the convenience payment market. Despite our graphical observation of a shift from credit to charge cards, the statistical analysis of this series indicated non-stationarity so the hypothesis that this was associated with the reforms has not yet been tested.

The 2003 reforms reduced a key price received by card issuers for the promotion of credit cards. This meant that from their perspective it was more costly to service card transactions and less desirable to have card customers. However, there is no evidence of a significant impact of that change and, indeed, where there is some associated change in the trended data, it is in the opposite direction from what was expected by the RBA at the time of the reforms.

3. Interchange Fee Neutrality

While some economic theory suggested that a reduction in interchange fees would have a negative impact on card use, it was recognised that this would only arise under certain conditions (Rochet and Tirole, 2002). In particular, Gans and King (2003a) showed that when surcharging was permitted and/or the retail economy was sufficiently competitive, changes in the interchange fee would be neutral. That is, interchange fee changes would alter relative prices but not the actual consumer choices over payment instrument usage.

This type of neutrality is *system neutrality*. It says that if there is a reduction in interchange fees by say, Δa, then merchant service fees will fall by the same amount, Δm. As noted in the previous section, this is what happened in Australia. But the price changes would not end there. Competition amongst issuers for card-holders would become less intense. Issuers used to receive Δa more for each card transaction they could encourage. Without that inducement they would have less incentive to promote such transactions. Hence, the marginal fee (which could be negative) which cardholders pay would rise. Say by Δf. Chang et.al. (2005) provide some evidence that that has occurred.

All this has the makings of a reduction in card-usage. However, if merchant service fees drop, then there will be some pressure from retailers to pass those savings on to consumers. This pressure could come from competition or alternatively it could come in the form of lower surcharges on credit card use. Either way, a consumer who opts to use a card may well face lower retail prices in so doing. In this case, while their inducement from banks to use cards has fallen, their inducement from merchants has risen. This is not to mention the fact that lower merchant service charges and permissions to surcharge themselves would mean that more merchants offer card services. In equilibrium, the system balances itself out and consumers end up making the same choices they made before any changes to the interchange fee occurred.

However, even system neutrality, allows for the possibility of temporary disruptions as relative prices adjust. Balanced against this, however, are the habits of consumers. Nonetheless, what it does predict is that once off changes to the interchange fee will have no lasting negative impacts on credit card usage. And that appears consistent with what we have observed in our econometric analysis.

Of course, the data is also consistent with *direct neutrality*. Interchange fees are only one of several types of payments made between issuers and acquirers. There are promotional incentives and the like although these tend to be less or not related to the volume of transactions. It is theoretically possible that as interchange revenue fell, these other payments adjusted accordingly to ensure that issuers continued to attract card-holders. Consequently, there may have been no change in card-holder fees and hence, a similar level of credit card use.

In either case, the implications for policy are very important. First, a constant but unregulated interchange fee will have the same level of credit card use as a constant regulated interchange fee. It is not an instrument for generating more efficient payment instrument choice nor reducing any perceived transaction costs in the payment system.

Second, even an interchange fee of zero, so long as it was constant, would give rise to the same market conditions – profits of issuers and acquirers, incentive for entry, merchant costs and consumer value and usage – as any other. However, it would save any need for accounting or settlement of interchange transactions.

In this sense, if neutrality were established, the RBA would have a free-hand in regulation. There would be no need to justify any particular fee as all fees led to the same real outcome. As I argue next, the alternative – regulating and on-going regulatory decisions – impose other costs. Thus, *treating interchange fees as if they were non-neutral is not, in of itself, neutral in terms of real resource costs*.

4. Regulatory Costs

If the interchange fee were neutral, then it might be argued that there were no costs of regulation as regulation itself would have no impact. In this case, the regulator might hedge their bets by regulating the fee regardless, just in case it turned out that it was effective and non-neutral.

However, regulation has its costs and these must be balanced against its effectiveness. In particular, I am not so concerned here with capping interchange fees and moving on. I am instead concerned with on-going re-calculations of those fees, auditing, enforcing, data collection, debating and reviewing. All of these activities are costly and also lead to uncertainty over what future interchange fees will be. There may be constant adjustment in an industry that did not see changes in interchange fees for over twenty years prior to regulation.

As an example of such costs, consider the inclusion of the costs of funding interest-free periods in determining the interchange fee. I argued in a previous submission that such a cost inclusion seemed appropriate given that payment functionality seemed to imply at least some interest free period to be of value to consumers.[4] However, I was concerned about the potential ability of banks to manipulate these costs by changing the length of that period and so argued for some averaging.

In hindsight, I am concerned that the assumptions upon which that conclusion was based may have been incorrect. According to the RBA's own data, there exist credit card accounts without an interest free period. Moreover, since October 2003, all of the new growth in credit card accounts has come from those with an interest-free period (see the earlier graph).

It is possible that it was the very fact that interest-free period costs were included in the interchange fee that caused issuers to ramp up marketing of those accounts to customers. Hence, the rapid growth in those accounts immediately following the reforms.

Recall that the reforms were supposed to create a disincentive to issue new credit cards compared with other payment instruments. However, the econometric analysis verified that an increase in the growth rate of accounts (specifically, interest free period accounts) was associated with the reforms introduction. Indeed, it remains the most visible impact of the reforms.

My suggestion here is that the unintended consequence of the way the interchange fee was calculated was to create a growth in interest free period accounts; the opposite of the direction the RBA was hoping for.

[4] Gans, J.S. and S.P. King (2002), "Regulating Credit Cards in Australia: A Submission to the Reserve Bank of Australia" http://www.rba.gov.au/PaymentsSystem/Reforms/CCSchemes/ResponsesConsultDoc/core_120302_1.pdf

To be sure, this is a potential example of the costs of regulatory intervention in an on-going sense. If the interchange fee were fixed, there may have been no distortion created.

In this respect it is very important to assess and form a view on neutrality. If the outcome is that the interchange fee is neutral, then it should be capped once and for all and no further reviews undertaken; certainly not annually. Indeed, there may be an argument for setting it at zero.

5. Conclusion

In this submission, I have argued that regulation of interchange fees has been ineffective. A typical response to this conclusion has been the following:

> It had been argued that, in the face of Reserve Bank actions on surcharging and access, regulation of interchange fees was unnecessary. The problem with this position is that, as argued above, card payment systems, left to their own devices, do not tend towards efficient operation. While in normal markets increased access could be expected to cure many anticompetitive ills, this was not the case in the credit card market. The structural features of the market are such that increased access to issuing or acquiring would not, of itself, overcome the problems with the inefficient setting of interchange fees: large subsidies to consumers that distort payment systems choice; relatively high costs to merchants who, in turn, pass those costs on to all consumers; and no effective resistance from merchants to inefficiently high charges. (Simon, 2005, p.376)

This response fails to distinguish between the efficiency of the system and the use of the interchange fee as an instrument for generating more efficient outcomes.

Put simply, it is hard to find any economic analysis that says that interchange fees set in an unregulated market will lead to efficient choices by consumers of payment instruments. Either the interchange fee is set arbitrarily (because it is neutral) or alternatively, it is set too high (Rochet and Tirole, 2002). If it is non-neutral and set too high, then capping is appropriate (Gans and King, 2003b) and indeed it can be argued that the RBA has been conservative in the fee that it has set (Gans and King, 2003c).

However, if it is neutral – as reforms such as surcharging would drive – then even if the system is not operating efficiently, the interchange fee cannot be used to generate that efficiency. It is an ineffective instrument. Payment systems are different because they are two-sided markets. That means regulation of one price only leads to the adjustment of others. If simultaneously the RBA could regulate all prices – interchange fees, card issuing fees and merchant service charges – then price regulation would be effective. The question would be: *how to regulate these to generate improvements in efficiency?*

6. References

Chang, H., D.S. Evans and D.D. Garcia Swartz (2005), "The Effect of Regulatory Intervention in Two-Sided Markets: An Assessment of Interchange-Fee Capping in Australia," *Review of Network Economics*, 4 (4), pp.328-358.

Gans, J.S. and S.P. King (2001), "The Role of Interchange Fees in Credit Card Associations: Competitive Analysis and Regulatory Options," *Australian Business Law Review*, Vol.29, No.2, April, pp.94-122.

Gans, J.S. and S.P. King (2003a), "The Neutrality of Interchange Fees in Payment Systems," *Topics in Economic Analysis and Policy*, Vol.3, No.1, 2003, Article 1.

Gans, J.S. and S.P. King (2003b), "A Theoretical Analysis of Credit Card Reform in Australia," "*Economic Record*, Vol.79, No.247, December 2003, pp.462-472.

Gans, J.S. and S.P. King (2003c), "Approaches to Regulating Interchange Fees in Payment Systems," *Review of Network Economics*, Vol.2, No.2, June 2003, pp.125-145.

Hayes, R. (2007), "An Econometric Analysis of the Impact of the RBA's Credit Card Reforms," *mimeo*., 26th August, Melbourne Business School.

Rochet, J-C., and J. Tirole (2002), "Cooperation among Competitors: Some Economics of Payment Card Associations," *RAND Journal of Economics*, 33, pp.549-570.

Simon, J. (2005), "Payment Systems Are Different: Shouldn't Their Regulation Be Too?" *Review of Network Economics*, 4 (4), pp.364-383.

An Econometric Analysis of the Impact of the RBA's Credit Card Reforms

by

Richard Hayes*

26th August, 2007

Abstract

On 31 October 2003 the average interchange fee for credit card transactions in Australia was lowered in a dramatic way – from 0.95% of transaction value to 0.55% of transaction value as part of a suite of credit card industry reforms, aimed squarely at reducing the attractiveness of credit card use relative to other payment instruments. This paper provides details of a battery of econometric tests indicating that this major set of credit card reforms in Australia failed to induce a negative structural break in credit card use. As well as tests assuming an exogenous break point we perform tests for a unit root versus the alternative of a single endogenously determined structural break and tests for a unit root versus the alternative of two endogenously determined structural breaks. The tests do not support a negative structural break in credit card usage levels, growth rates or market shares at the time of the reforms. They do however suggest a positive structural break in credit card accounts.

* Melbourne Business School, University of Melbourne. The author is also a casual employee of the Australian Competition and Consumer Commission. The views expressed in this paper represent those of the author and should in no way be construed as representative of the above organizations. Responsibility for all errors and omissions lies with the author.

Table of Contents

1. Introduction

On 31 October 2003 the average interchange fee for credit card transactions in Australia was lowered in a dramatic way – from 0.95% of transaction value to 0.55% of transaction value. The Reserve Bank of Australia mandated this reduction as part of a suite of credit card industry reforms. The reduction in the interchange fee was aimed squarely at reducing the attractiveness of credit card use relative to other payment instruments. This paper provides details of a battery of econometric tests to determine if this change was associated with a structural break in the use of credit cards. In other words, *can the change in interchange fee be linked in a statistical sense with structural breaks in the time series data for credit card transaction values, credit card account numbers and credit card market shares?*

The approach is to use Chow type tests for an exogenous structural break on series that appear stationary. This is followed by tests for a unit root versus the alternative of a single endogenously determined structural break and tests for a unit root versus the alternative of two endogenously determined structural breaks.

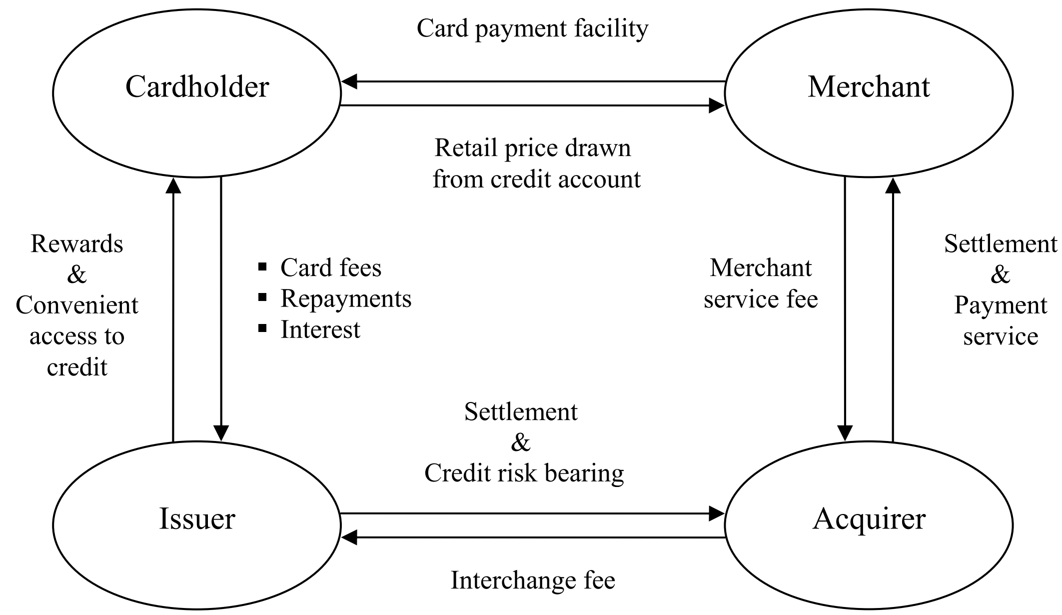
The paper outline is as follows. Section 2 outlines the relevant features of credit card systems. The recent regulatory reforms are explained and put in context in Section 3. Section 4 explains the econometric approach. Section 5 details the unit root tests and results. Section 6 outlines the Chow type tests and results for an exogenous break. Section 7 provides the rationale and results for testing for a single endogenously determined structural break and Section 8 does likewise for tests for two endogenously determined structural breaks. Section 9 summarises the main findings and Section 10 concludes.

2. Background to credit card systems

A credit card transaction is typically a four party transaction, as outlined in Figure 1. The credit card transaction has the credit card holder offering the merchant the right to draw the retail price from the cardholder's pre-existing line of credit with the issuing bank. The merchant exchanges this right with its own bank, the acquirer, in exchange for a merchant service fee. The acquirer in turn settles the debt with the issuing bank and pays the issuing bank an interchange fee to compensate the issuing bank for the costs of settlement and bearing the credit risk. The issuer ultimately recovers the debt from the cardholder, potentially along with other fees from the cardholder. They may also recover interest depending on whether or not the card has an interest free period and whether or not the cardholder repays the balance during this period.

In some cases a single institution acts as both the acquirer and the issuer due to their relationship as both the cardholder's and merchant's service provider. This contrasts with the situation of American Express and Diners Club which are three party card schemes. In each of their own schemes American Express and Diners Club act as the sole issuers and acquirers. Their flagship cards are also charge cards, featuring an interest free period but requiring repayment in full each month.

Figure 1 Flow of exchanges in credit card transactions



The credit card transaction has four parties and there is joint consumption and supply of the service. The cardholder and the merchant jointly consume the credit service and the issuer and acquirer jointly provide the credit service. The credit card industry is frequently characterised as a 2-sided market: one where the credit card industry acts as a platform that must attract both sides of the market, cardholders and merchants (Baxter, 1983; Evans, 2003; Rochet & Tirole, 2003, , 2006; Schmalensee, 2002). In two sided markets any changes to fees must consider the impacts on both sides of the market. Cardholders value credit cards to an extent largely influenced by how widely accepted the cards are by merchants and affiliated merchants care greatly about the prevalence of cards among consumers.

2.1 Cardholders

Cardholders receive several benefits from using credit cards for transactions. First is the convenience feature. Cardholders have reduced need to carry cash and have access to a normally relatively secure mode of payment. A second key benefit is access to a pre-approved line of credit. Depending on the card there may be access to this credit interest free for a period, although access for longer results in interest charges.

These primary benefits may be enhanced by the waiver of fees or the provision of rewards for card use. Rewards such as frequent flyer points are effectively a negative price attached to the use of credit cards and are designed to increase their usage. The primary benefits are also enhanced by the size of the network of accepting merchants. The wider the merchant network the greater the convenience of the credit card.

These benefits are weighed up by cardholders against the costs accompanying card usage, including annual card fees, any transaction fees and potential interest charges on unpaid balances. The relative benefits are then weighed up against alternative forms of payment such as cash, checks, debit cards and charge cards.

2.2 Merchants

Merchants receive some direct benefits from credit card transactions. Transactions with credit cards have security benefits in the form of protection for the merchant against fraud and customer credit risk. There is a convenience factor to electronic transactions, with potential benefits in subsequent accounting. Some merchants do not have a physical presence to allow other payment methods such as cash. Merchants also receive a key indirect benefit from credit card transactions – incremental profits from sales to customers who only or preferentially shop using credit cards. These are affected by the competitive environment faced by the merchant – especially the degree to which other merchants also offer credit card facilities. These benefits come with costs associated with providing credit card payment infrastructure, per transaction merchant service charges paid to acquirers and some annual fees.

2.3 Fees

The issuers and acquirers both incur transaction costs. Issuers receive interchange fees from acquirers and fees and interest from cardholders. Acquirers receive the merchant service fee from merchants.

Credit card interchange fees can be set several ways. In the case where the issuer and the acquirer in the transaction are different entities then they have to have a way to set the interchange fee and to share the risks of the transaction. One option is bilateral negotiation between the issuer and the acquirer. Another is central setting of fees and conditions, either by the association or by a regulator.

Historically credit card associations such as Mastercard and Visa have centrally set interchange fees that members of the association then pay each other for the transaction services. In this situation the members of the associations, typically banks and other credit institutions, effectively cooperate to set the price that they charge each other for these services. This cooperative price setting by the players themselves has raised questions of potential efficiency and anti-competitive impacts for regulators in several countries (Cruickshank, 2000; European Commission, 2000; Reserve Bank of Australia and Australian Competition and Consumer Commission, 2000). There have been several antitrust cases in this area in the United States, see Evans and Schmalensee (2005) for further details.

Australia’s interchange fee arrangements have largely reflected those of other countries, being cooperatively set by the members of the Bankcard, Mastercard and Visa associations. Until the regulatory changes the associations set the interchange fee level at an average level of approximately 0.95 percent of transaction value (Reserve Bank of Australia, 2004).

To the acquirer the interchange fee is a cost that may or may not be passed on at all to the merchant. The degree of competition between acquirers would be expected to affect the degree to which the interchange fee is passed on. The merchants pay the acquirer a merchant service fee which reflects the degree to which the interchange fee is passed on by the acquirer and a component for the cost of the transaction services provided by the acquirer.

3. Regulatory reforms

3.1 Early concerns

Australia's payment system was identified as a critical area by the "Wallis Inquiry" (Financial System Inquiry, 1997). The report recommended for the Reserve Bank of Australia (RBA) establish a Payments System Board, for the Australian Competition and Consumer Commission (ACCC) to continue to apply the Trade Practices Act to questions of access to the payments system and for the ACCC and the Payments System Board to review aspects interchange fee arrangements. The passing of the Payment Systems (Regulation) Act in 1998 bestowed powers on the RBA to designate the payment system and regulate payment systems standards, including pricing terms.

A subsequent joint RBA and ACCC study elevated three particular concerns about the payment systems relevant to the credit card market (Reserve Bank of Australia and Australian Competition and Consumer Commission, 2000). First was the use of no surcharge rules. These rules, imposed by the associations on merchants, forbid the use of credit card surcharges by the merchants. This means merchants are unable to recover the costs of merchant service fees directly from the cardholders. Instead merchants recover the merchant service fees by increasing prices to all consumers. That is, they increase prices for both card users and non card users. This has the effect of imposing the costs of credit card transactions across all consumers.

The second area of concern was the restrictions placed on entry to the associations. Mastercard and Visa restrict participation in the associations by explicitly requiring card issuers to be authorised deposit taking institutions. Prospective Bankcard members required the unanimous approval of the four remaining founding banks – Australia and New Zealand Banking Group, Commonwealth Bank of Australia, National Australia Bank and Westpac Banking Corporation. The rationale of such entry rules is to protect existing association members as their "honour all cards" policy means they provide ultimate guarantee of payment to merchants. So association members are concerned with the credit worthiness of other members.

Concerns were raised that requiring members to be authorised deposit taking institutions was more stringent than necessary to ensure the security of the card association. Additional concerns surrounded the requirement for acquirers to also be issuers, which in effect required them to be authorised deposit taking institutions, and the effect of association membership fees. We do not explicitly explore the changing regulation landscape in this area except to point out the timing of these regulatory changes as potential alternative sources of breaks in the time series data for credit card transactions and their chares of the various payments markets.

The third area of concern and the primary concern of this paper was the setting of interchange fees. In Australia interchange fees are only applied to card networks. Payments made by cheque, direct credit or direct debit do not have interchange fees. Instead the institutions providing these transaction instruments aim to recover their costs from the actual direct users of the instrument.

The setting of interchange fees was of particular concern in conjunction with the no surcharge rule. Since a merchant can not pass the costs of cardholder transactions directly to cardholders they instead recover the costs of cardholder transactions by increasing prices for all consumers. So increases in the interchange fee that are passed on in the form of the merchant service fee are in turn passed on to all consumers, whether they use credit cards or not.[1] The issuer receives the interchange fee and has an incentive to increase credit card usage among cardholders at the expense of other payment methods. The cardholders receive increased incentives to use their cards but only face the increase in price faced by all consumers. So the cardholders face a negative price for using the cards and the price of using cards at the merchants is lower than the costs of the card transaction. So there is overuse of the cards and credit card users are subsidised by other consumers.

This encouragement of credit card services via a negative price for cardholders proved to be a key concern of the RBA and ACCC. The tendency for this to promote the use of credit cards over alternative lower cost payment methods was an issue raised in the study and was a key driver of subsequent regulatory change.

3.2 Timeline of reforms

Following designation of the Mastercard, Visa and Bankcard associations in April 2001 and subsequent consultation the RBA published final standards governing the interchange fee and the no surcharge rule in August 2002 (Reserve Bank of Australia, 2004). The no surcharge standard came in to effect on 1 January 2003 and the interchange fee standard came into effect 1 July 2003. However the interchange fee standard did not require any change to the interchange fee until 31 October 2003. Accordingly the fees actually changed on 31 October 2003, closely after the Federal Court rejected a Mastercard and Visa legal challenge to aspects of the reforms in September 2003.

As a result interchange fees fell from approximately 0.95 percent before the interchange fee reform to 0.55 percent immediately after (Reserve Bank of Australia, 2004). A further reform to move to a common interchange fee across both of the associations came in to effect from 1 November 2006. The size of the change in interchange fee from this reform was much smaller. Separate access standards were finalised in February 2004.

Regulation of the fees would have appeared increasingly likely over this timeline. Banks could have made some initial moves in anticipation of the decreased interchange fee. However right up until the time of the interchange fee change marginal transactions were worth the same to the issuers that they had always been. So while issuers may have begun anticipating the changes it is unlikely that they would have had a direct effect on the issuers' willingness to promote card usage, until the interchange fee actually changed.

It is more likely that issuers would begin a process of recovering more of their costs in the form of increased annual fees for cardholders. They may also have become more circumspect in the types of cards being offered so as not to promote a generation of new cards that would be less profitable in the future. This would particularly affect cards as they were renewed or initiated and which would allow the market response

[1]No surcharge rules do not appear to prohibit discounts for cash payment. Despite this, discounts for cash appeared to remain the exception rather than the rule.

could be monitored. This contrasts with any attempts to directly increase charges for transactions which would be expected to immediately reduce transaction rates for existing and new cardholders, with an immediate consequent impact on interchange fee revenue. Furthermore the issuers would have been hopeful of their court challenge obviating the need to tinker with their charging structures.

In November 2004 the RBA noted that “most credit card issuers have restructured their credit card offerings and pricing over the past year” (Reserve Bank of Australia, 2004, p. 11). The changes noted by the RBA include increases in annual card fees, increases to spending needed to gain rewards and caps to rewards points. These were offset somewhat by the increasing emergence of lower interest rate card options. Continued similar changes were reported by the RBA in 2006 (Reserve Bank of Australia, 2006).

For these reasons we anticipate that the primary effect on credit card transaction value would be from the time of the change to the interchange fee. From that point in time each incremental dollar’s worth of credit card transactions was worth considerably less to the issuers than before. Cardholder behaviour could be sticky in some respects of responding to the changes so later we model the change in behaviour as both sudden mean shifts (intercept changes) and gradual mean shifts (time trend changes). However we maintain that the starting point for looking for effects from changes to the interchange fee should be the date of the fee change itself, while remaining cognisant of other potential break dates resulting from other credit card reforms.

3.3 Neutrality

It is clear that the RBA expected the change in the interchange fee, as well as the other reforms, to reduce the relative attractiveness of credit cards versus other payment instruments by reducing elements of perceived subsidy towards cardholders (Reserve Bank of Australia, 2001). The inference from this is that the level of the interchange fee significantly affects credit card transaction levels.

This would be consistent with credit card markets being two sided, in the sense defined by Rochet and Tirole (2003) and refined in Rochet and Tirole (2006). They say that a market with network externalities, such as credit cards, is a two sided market if platforms can cross subsidise different categories of end users in the transaction. So in two sided markets transaction levels are affected by how prices are distributed between merchants and cardholders, not merely on the total level of charges levied.

An alternative view is that the credit card system is essentially neutral with respect to the interchange fee. This view says that the interchange fee has no impact on the size of the credit card system. Changes to the interchange fee would result in changes to prices such as merchant service fees, prices and cardholder fees but would leave unchanged consumer decisions about card use and merchant decisions about accepting cards. That is, credit card transaction volume would remain essentially unchanged.

A critical area of theoretical development in credit card markets has been analyses of when credit card markets are expected to be neutral and when interchange fees are expected to have real economic effects. Carlton and Frankel (1995) show that perfect competition at the issuing, acquiring and merchant level means any change to the interchange fee flows through to all prices including prices paid to merchants. So the fee causes no change in cardholder and merchant behaviour. Under these circumstances the interchange fee is neutral. In a later development Wright (2003) shows that perfect competition at the retail level is sufficient to ensure neutrality in a specialised model. When surcharging is allowed Rochet and Tirole (2002) show in a particular model where issuers have market power and acquirers have no market power that changes to the interchange fee are ultimately passed through to cardholders via higher surcharges for card use – the fee is neutral.

Gans and King (2003a) prove a more general result that whenever "payment separation" occurs the interchange fee is neutral. Payment separation "requires that all customers who purchase goods and services 'at a credit card price' from a merchant offering credit card services do indeed use credit cards" (page 3). That is, cash paying customers do not pay the merchant's credit card price.

This condition is effectively satisfied by either of the conditions outlined by Carlton and Frankel (1995) or Rochet and Tirole (2002). Where there is the ability for merchants to set separate cash and credit card prices then at any merchant credit sales occur at one price and cash sales occur at another. Alternatively if separate prices are not achievable by single merchants then market competition may be sufficient to ensure payment separation via a market split between cash only merchants and credit card only merchants. With payment separation, theory would predict that the interchange fee would be neutral.

The implementation of the merchant pricing standard on 1 January 2003 means that by the time the change in interchange fee was mandated on 31 October 2003 there had been several months of potential credit card surcharging by merchants. Theory would suggest that the implementation of surcharging would remove the need to mandate the credit card interchange fee (Gans & King, 2003b). However concerns have been expressed that even if surcharging is allowed merchants may not make use of the option due to excessive transaction costs (Frankel, 1998; Reserve Bank of Australia, 2001). In that case it is possible that the interchange fee would not be neutral.

The results of the actual takeup of the surcharging option are not definitive however the RBA has highlighted the wide range of industries where surcharging has actually occurred.[2] This provides some indication that merchants are not overly constrained from using surcharging.

---

[2] Industries where merchants can be found surcharging include airlines, business suppliers, computer retailers, clubs, councils, fashion retailers, furniture retailers, government departments, hotels, hardware and gardening retailers, kitchen manufacturers, motorways, removalists, restaurants, schools, supermarkets, travel agents, utilities, telecommunications, bars, whitegoods and electrical retailers. (Reserve Bank of Australia, 2004, , 2005)

3.4 Empirical expectations

The RBA's move to reduce interchange fee provides a natural experiment. At the most specific level it allows tests for the impact of the reform on credit card transaction growth levels, credit card market shares and credit card account numbers.

At a more general level it also provides a forum for testing whether Australian credit card markets are two sided markets in the sense of Rochet and Tirole (2003) or neutral in the sense of Gans and King (2003a) with respect to interchange fees. Using these definitions, a credit card market is two sided if the interchange fee matters for credit card transaction levels. Alternatively credit card markets may be neutral in the sense that changes in a price like the interchange fee pass through the system, with other prices adjusting and transaction volume remaining unchanged.

So if the Australian credit card market is not neutral then we would expect the RBA interchange fee reform to make a difference to credit card transaction levels. The massive size of the change to the interchange fee means that if the Australian credit card system is not neutral that we would expect to see real effects – not on prices but on transaction levels.

In this scenario we would expect merchants to be more attracted to receiving credit card payments for goods and services, as their merchant service fees have declined with the reduction in interchange fees. However using credit cards would be less attractive for cardholders as their banks receive lower interchange fees and so are less encouraging of credit card use. For example rewards for credit card use could be cut, fees for holding and using a card could be increased. Consumers make the ultimate decision about the choice of payment instrument. So if the interchange fee is not neutral we would expect a reduction in the interchange fee to lead to a reduction in the volume of credit card transactions and an increase in transaction volumes for other instruments such as cash, cheques, debit cards and charge cards. In this scenario we would expect a reduction in relative credit card transaction value growth and an increase for debit cards, cash, checks and charge cards.

4. Econometric approach

On 31 October 2003 the interchange fee for credit card transactions was lowered in a dramatic way – from 0.95% of transaction value to 0.55% of transaction value. This section provides details of tests to determine if this change was associated with a structural break in the use of credit cards. In other words, *can the change in interchange fee be linked in a statistical sense with structural breaks in the time series data for credit card transaction values, credit card account numbers and credit card market shares?*

The various types of structural break and the issues arising in testing for them in univariate and multivariate time series models have spawned a large literature. Testing for unit roots and breaks in a univariate setting has been notably advanced by Perron (1989), Perron and Vogelsang (1992), Zivot and Andrews (1992), Lumsdaine and Papell (1997) and Ben-David, Lumsdaine and Papell (2003). These techniques feature in the econometric tests to come. These tests variously assume that the structural break is known or unknown, that the break is a result of a shift in the level or a shift in a deterministic trend or both and that there is one break or two. As Saikkonen and Lütkepohl (2000) have noted the overall message from these studies is how structural breaks can create trouble for ordinary inference methods.

A particular dilemma is choosing between the known exogenous date of the actual interchange fee change and using a break point date endogenously determined by the actions of agents in the credit card market. Econometric techniques that test for endogenous structural breaks have been developed (see Maddala and Kim (1998) for a summary) and techniques are also available for confirming the existence of known or assumed breaks (Chow, 1960; Perron, 1989).

Here the date of change of the interchange fee is well known. So initially we follow Maddala and Kim's suggestion (1998, p. 398) that where there is prior information about the timing of drastic policy change tests for breaks should be around those events. We supplement this with testing for endogenously determined break points.

Early tests for structural change tended to simply assume the data was non-trending or stationary (Abubader, 2002). Exogenous breakpoint tests such as the Chow type tests generally require stationarity. Without stationarity there is reduced robustness for the Chow test as there is a high chance that if a different period had been chosen as the potential break point it would be found to be a potential break. In effect in a unit root process permanent shocks occur frequently. In a trend process with a structural break or two, such shocks occur relatively rarely. Without stationarity the OLS estimates from a Chow test for a structural break are likely to be biased and unreliable.

We perform unit root tests to help determine which series are suitable for testing using Chow type tests. For series where we are able to reject the null of a unit root we proceed to perform Chow type tests for a structural break. Where we fail to reject the null of a unit root we do not perform Chow type tests for a structural break.

For all series we then proceed to test for endogenously determined breaks. We test for a single endogenously determined break using the methodology of Zivot and Andrews (1992). We then proceed to test for two endogenously determined structural breaks using the method of Lumsdaine and Papell (1997).

4.1 Data series selection

The primary tests were done using credit card and other payment data extracted from the RBA website. The series tested are described in Table 1, including the construction of various credit card market share measures. The data series are monthly. They focus on purchases not cash advances.

The market share figures are more directly indicative of the effect of the change in the interchange fee on the relative preference for credit cards. The credit card transaction value and credit card account numbers are still indicative of whether or not the interchange fee change had an absolute effect in these areas.

For credit cards and debit cards the data series extends from May 1994 to June 2007. For charge cards, cheques and direct debit data is available from January 2002 to June

2007. In January 2002 a major revamp of payments system data collection occurred (Reserve Bank of Australia, 2003). This led to severe breaks in most of the credit card and debit card data series. Many more institutions were included in the survey, commercial credit and charge cards became included, general purpose charge cards became included in the primary credit card statistics and some signature based debit cards were reclassified from credit cards to debit cards.

As a result of these data collection changes most elements of the credit card and debit card series tend to exhibit clear severe breaks at January 2002, breaks that are all the more notable where they are in the opposite direction to the normal annual seasonal decline going from December to January for these series. In general these reporting breaks appear so large as to make tests for other statistical breaks problematic when looking back beyond January 2002.

So the extended series are likely to be affected by the data collection change. Still the series extending back to May 1994 does allow tests over a longer timeframe. We perform these tests, mindful of the potential for the change in data collection methodology to interfere with the search for breaks. As we shall see several regression results are clearly affected by this and we are cautious in analysing results from these extended series. [3]

Accordingly we use the data series from January 2002 for the primary regressions. We also have regression results using data from May 1994 for credit card transaction value, credit card account numbers and credit card share of the credit and debit card market. Early observations are used for lags where necessary.

The other notable analysis in the literature taking an econometric approach to assessing the credit card reforms is Chang, Evans and Garcia Swartz (2005). They do some graphical analysis and also look for changes in quarterly and annual growth rates in credit card use. They do not find evidence of significant impact from the reforms except, possibly, some positive impacts. This analysis was done at a relatively early stage after the reforms. The analysis of credit card transaction volumes does not appear to fully consider aspects of the time series properties of the data, in particular seasonality and stationarity issues.

In terms of the data series used, Chang et al. (2005) appear to aggregate the regulated four party credit card data with some unregulated charge card data in some of their analysis. Although credit cards represent around 80% of the combined credit and charge card data using this series makes it difficult to test for shifts between credit cards and other payment methods, including charge cards themselves. They also appear to use data series affected by the break in data collection methods referred to earlier. It is unclear how they dealt with the major shift in payment system data collection methods from January 2002.

[3] A much smaller reporting break also occurred in March 2000 when a reporting change by a bank affected the number of credit card accounts.

Table 1 Variables & Definitions

VARIABLE	FULL NAME	DERIVATION	SOURCES
Credval	Credit card transaction value (millions of June 2005 AUD)	Total real value of transaction purchases involving credit cards. It is the sum of transaction purchase value during the month for cards with an interest free period and those with no interest free period. It excludes cash advances.	Additional Credit Card Statistics (Reserve Bank of Australia, 2007a) Consumer Price Index, Australia (Australian Bureau of Statistics, 2007b)
Credaccts	Number of credit card accounts ('000)	Total number of credit card accounts. The sum of credit card account numbers for cards with an interest free period and those with no interest free period, as at month end.	Additional Credit Card Statistics (Reserve Bank of Australia, 2007a)
Credsharetotal	Credit cards share of total "convenience payment" market	Total credit card purchase transaction value divided by the total value of purchase transactions for credit, charge and debit cards*, customer cheques and direct entry debit transfers. It doesn't include financial institutions cheques, direct credit or cash.	Bulletin table C1 - Credit and Charge Card Statistics (Reserve Bank of Australia, 2007b) Additional Credit Card Statistics (Reserve Bank of Australia, 2007a) Bulletin table C4 - Debit Card Statistics (Reserve Bank of Australia, 2007c) Bulletin table C5 – Cheques and Direct Entry Payments (Reserve Bank of Australia, 2007d)
Credsharecards	Credit cards share of total card market	Total credit card purchase transaction value divided by the total purchase value of transactions for credit, charge and debit cards*.	Bulletin table C1 - Credit and Charge Card Statistics (Reserve Bank of Australia, 2007b) Additional Credit Card Statistics (Reserve Bank of Australia, 2007a) Bulletin table C4 - Debit Card Statistics (Reserve Bank of Australia, 2007c)
Credsharecreddeb	Credit cards share of total credit card and debit card market	Total credit card purchase transaction value divided by the total purchase value of transactions for credit cards and debit cards*.	Additional Credit Card Statistics (Reserve Bank of Australia, 2007a) Bulletin table C4 - Debit Card Statistics (Reserve Bank of Australia, 2007c)
Credsharecredchar	Credit cards share of total credit card and charge card market	Total credit card purchase transaction value divided by the total purchase value of transactions for credit cards and charge cards.	Bulletin table C1 - Credit and Charge Card Statistics (Reserve Bank of Australia, 2007b) Additional Credit Card Statistics (Reserve Bank of Australia, 2007a)

* Debit card data separating purchases from cash withdrawals is only available from August 2002. To extend the series back beyond this date we have used total EFTPOS transaction data for the debit card data series. This includes a small (~10-15%) cash withdrawal component.

4.2 Time series plots

The series examined are plotted in Figures 1, 2, 3, 4, 5 and 6. The real credit card purchases series credval in Figure 1 appears to be seasonal, with December standing out as a peak and January appearing to be a low point. This seasonality is also apparent for the shorter credit card transaction series from January 2002 to June 2007. The peak retail season in December would explain this apparent seasonality.

Credit card account numbers generally increase over the time period examined as shown in Figure 2. The increase is from credit cards that have an interest free period. In fact there was a decline in the number of credit cards held without an interest free period. The break due to a change in data collection methodology in January 2002 is obvious from the graph. There is also some visual evidence of a break at the time of the interchange fee decrease, with credit card account numbers having a marked **increase** from October 2003 to November 2003.

Visual inspection of the market shares graphs suggests a number of things. There appears to be a small increase in the credit card market share for these markets over time since January 2002. No structural break is readily discernible from Figure 3, the graph of credit card market share of total convenience payment market although there is a significant drop in June 2007, the last month of data. There was a large increase in direct entry payments for June 2007, almost 20% over the value for June 2006. A possible explanation for this is that it reflects a redistribution of financial assets among Australians preparing for changes in superannuation laws from July 2007. Future movements should indicate whether this is a sustained change in behaviour.

Figure 4, the credit card share of the total card market, could indicate a slight reversal of trend around the time of the reforms. More noticeably, this series has a distinct “sawtooth” pattern, for reasons that are not clear to us. This could be an artefact of the primary data collection method such as different banks being sampled differently in different months. It is cause for some caution in interpreting results for this series.

The credit card share of the credit and debit card market is shown in Figure 5. An initial down trend is followed by a sustained increase in credit card market share from early 1997. This shift is probably due to consecutive 0.5% interest rate decreases in November and December 1996 and the rising prevalence of frequent flyer incentives for credit card users. There is also a large break after the change in data collection methodologies in January 2002. Following this is a period of relative stability in credit card market share. The shorter January 2002 to June 2007 series is likely to be more reliably modelled than the extended series here.

Figure 6 and the underlying data for the credit card share of the credit and charge card market indicate the potential for a small negative structural break of ~1-2% market share around March and April 2004, a few months after the reforms.

The underlying data used in constructing these market shares has not been seasonally adjusted. The graphs do not suggest strong seasonality in market shares although there does appear to be some “peaking” in December for the credit card market share of the total convenience payment market and of the credit and charge card market. Separate inspection of correlograms for these series suggests some potential for seasonality with a 12 month lag. The seasonality and unit root tests to come will assume the market share series and the log of credval and credaccts have a deterministic trend, until tests indicate otherwise.

Figure 1 – Real credit card purchases

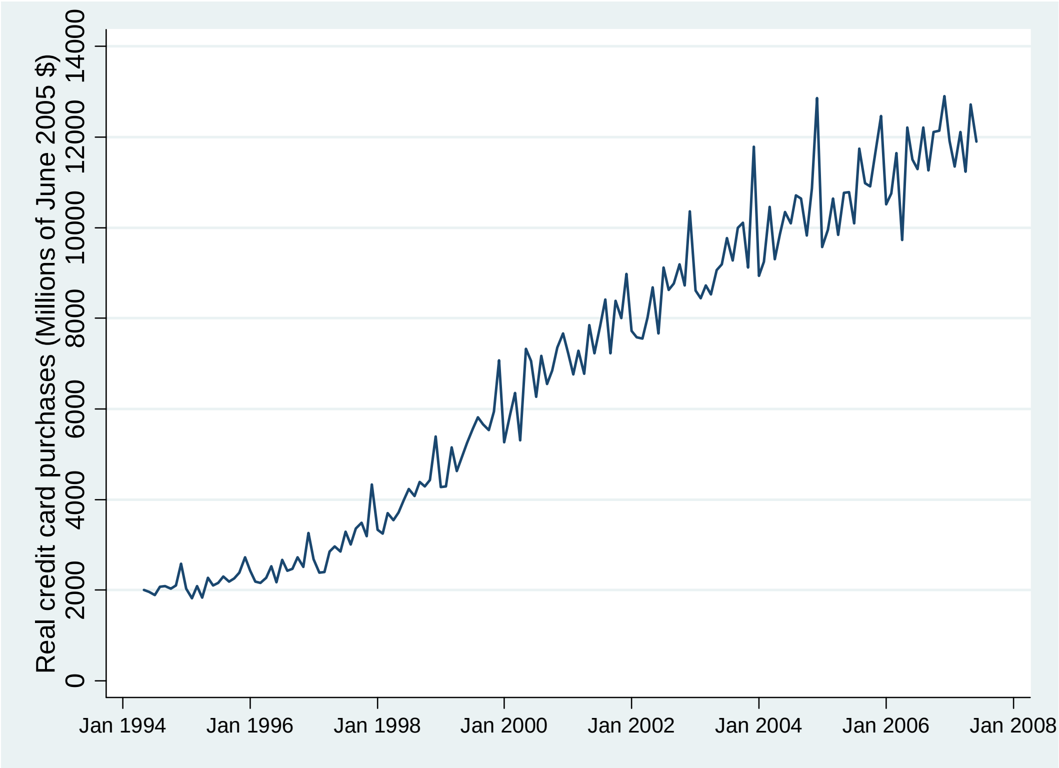


Figure 2 – Credit card account numbers

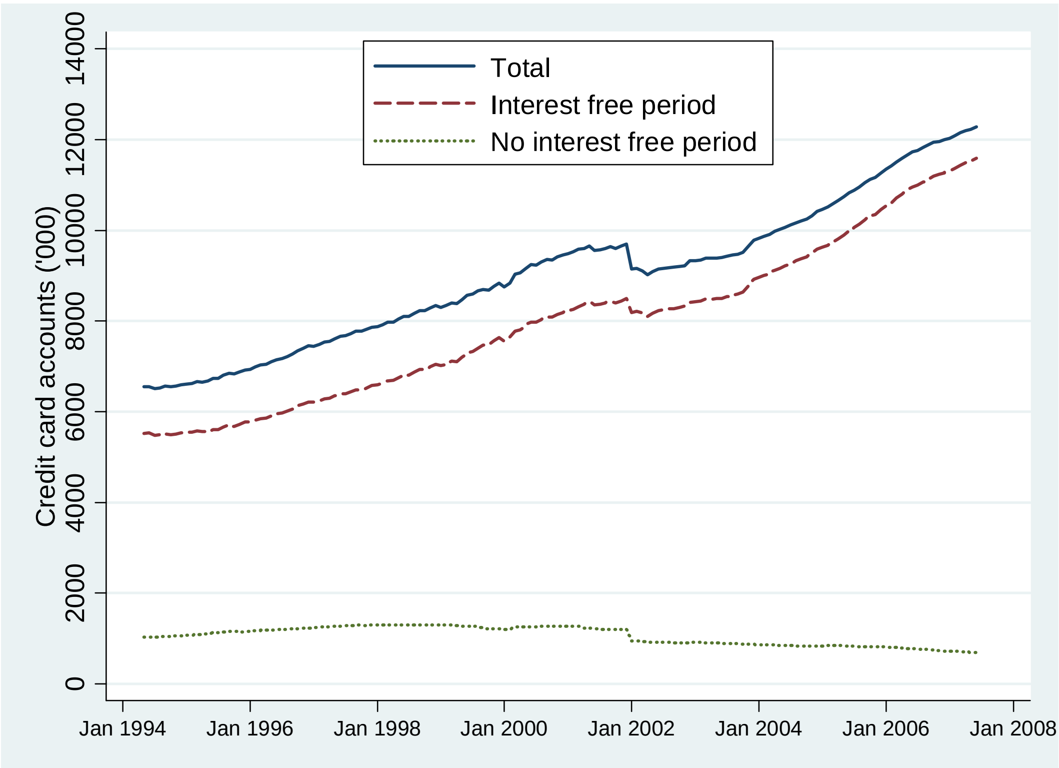


Figure 3 – Credit card share of total convenience payment market

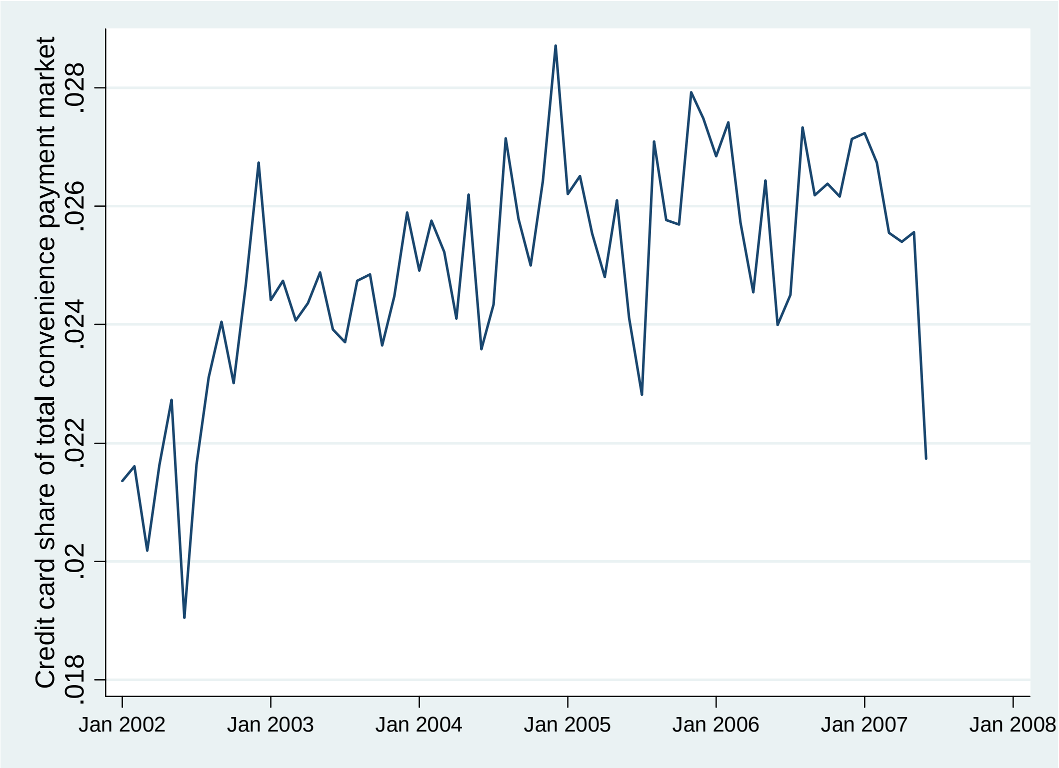


Figure 4 – Credit card share of cards market

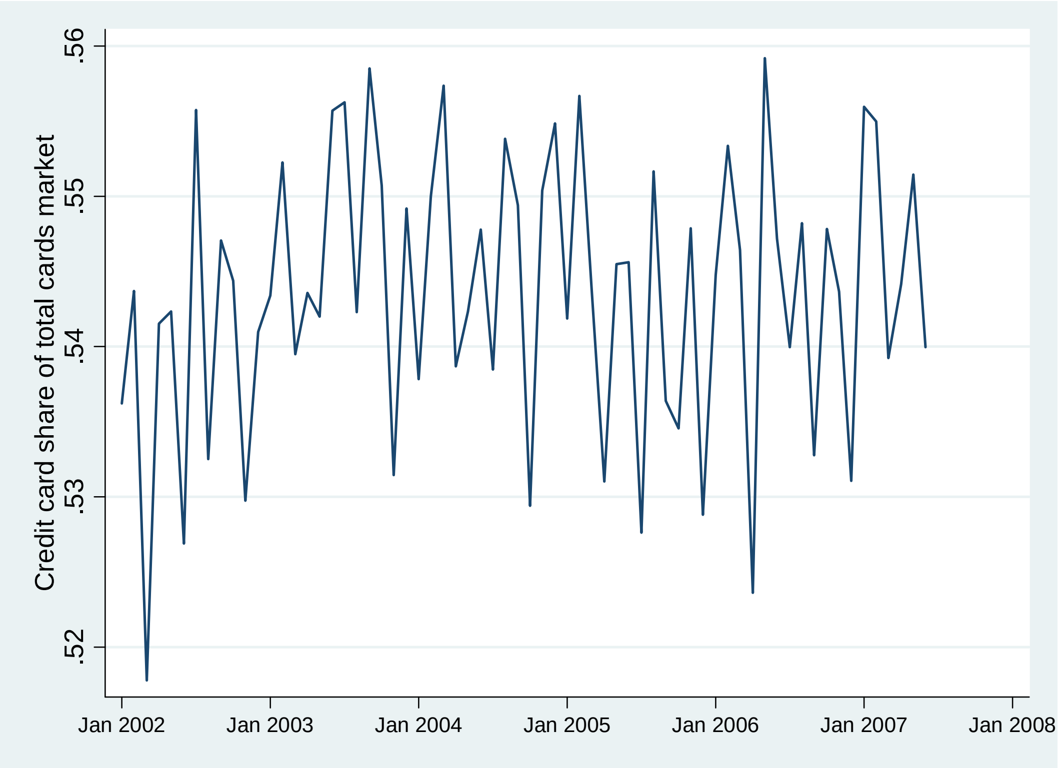


Figure 5 – Credit card share of credit & debit card market

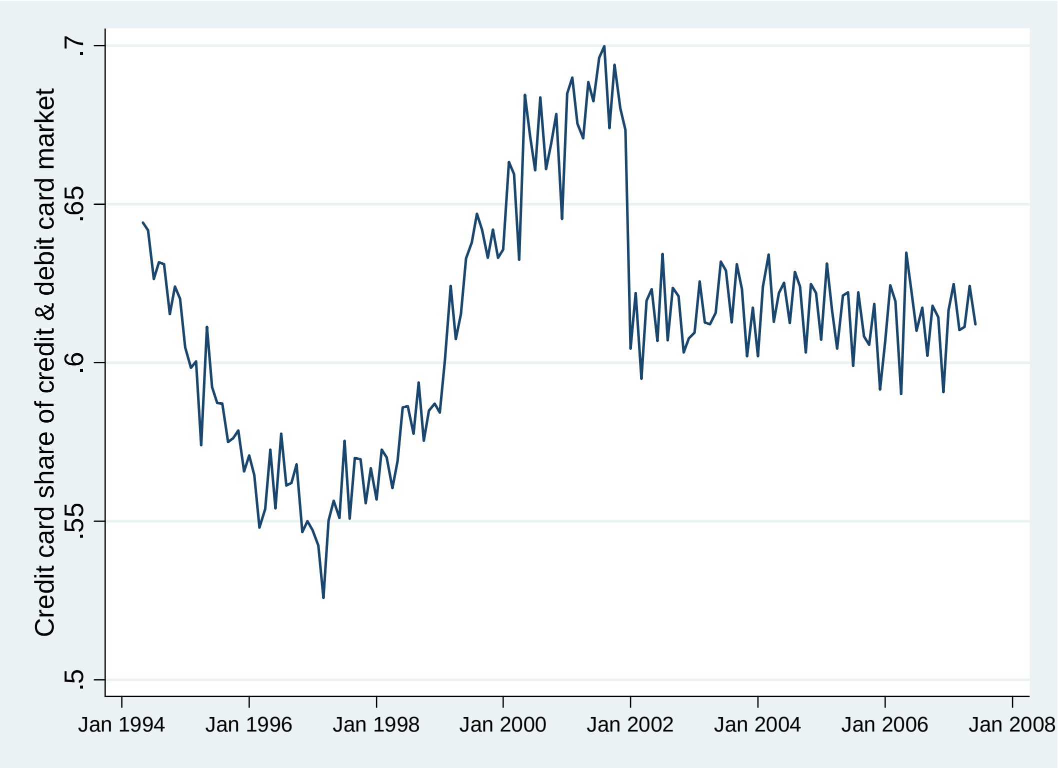
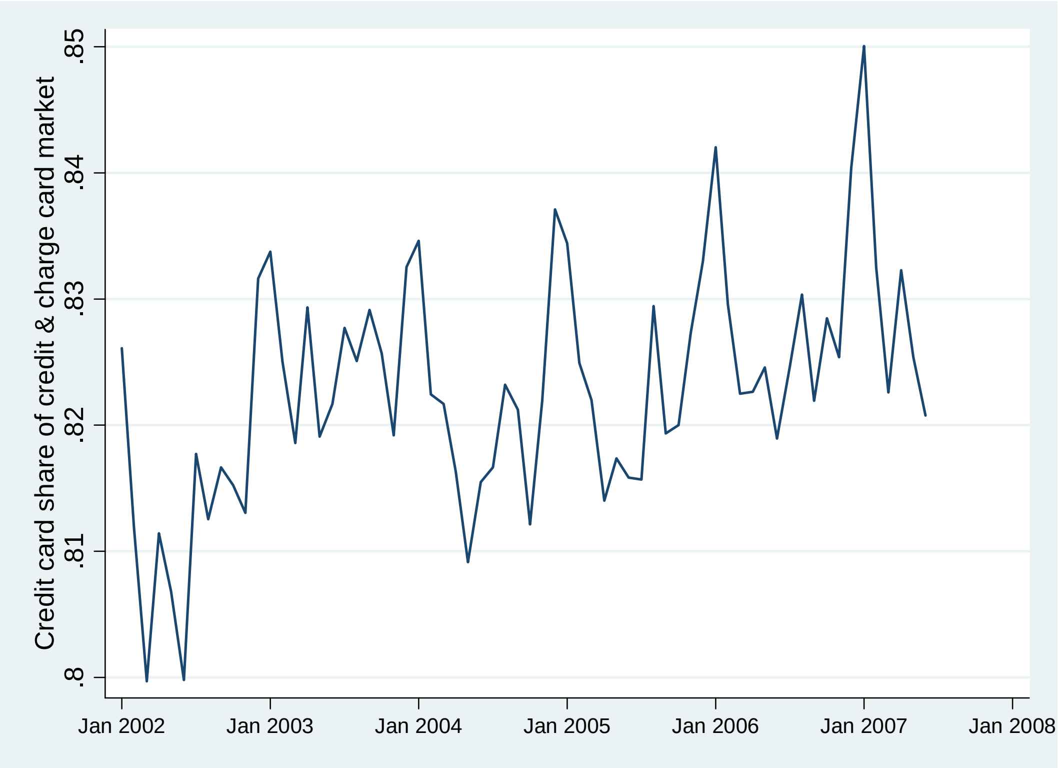


Figure 6 – Credit card share of credit & charge card market



4.3 Seasonality tests

The RBA data is not seasonally adjusted. We deal with potential seasonality by using seasonal dummy variables. This relies on an assumption of deterministic seasonality. Although tests exist for seasonal unit roots, such as the families inspired by Hylleberg, Engle, Granger and Yoo (1990) and Dickey, Hasza and Fuller (1984), we are somewhat restricted in having only 5-6 data points for each month in the primary series. In particular, the primary series have only 1-2 data points for each month prior to the break date of 31 October 2003.

In any event, we consider this deterministic seasonality assumption reasonable, following the arguments of Miron (1996). The seasonal dummy model is likely to be a good approximation for credit card markets, where much of the seasonal variation would be anticipated to be associated with relatively unchanging underlying events – the timing of certain holidays and changes in the weather producing regular increases and decreases in retail sales and resulting credit card usage. The fluctuations caused by these underlying factors will not be identical in all years. However a good first approximation will be that the seasonal effects, associated with say December, will still be apparent independent of the state of the business cycle.

Testing for seasonality involved performing a regression of each series on a time trend, a constant and a set of 11 monthly dummies. Table 2 highlights the results. An F-test of joint significance of the dummies was used to test seasonality. We included a time trend for the series based on the potential for underlying trends observed from the time series plots of the variables in levels and in logs. The t-tests on the time trend supported this for the series in levels and some of the market share series. These seasonality findings were unchanged if the time trend was dropped. In our unit root tests we will assume the most general model including a time trend initially.

Due to the potential for serial correlation we used heteroskedasticity and autocorrelation consistent standard errors (Newey & West, 1987). Following the suggestion of Wooldridge (2003) we did not use the alternative of Feasible GLS as it would usually mean assuming the errors follow an AR(1) model and we prefer the OLS estimates to be robust to more general forms of serial correlation.

The credit card transaction value series were all strongly seasonal. December was easily the biggest source of seasonal difference from the January baseline.

For credit card account numbers, the joint test of significance did not indicate seasonality in the presence of a time trend. Testing for seasonality in the 1^{st} difference of the credit card accounts series was problematic. Using Newey West standard errors the joint test of seasonality for the 1^{st} difference only barely failed to reject the null hypothesis of no seasonality and there were individual December results significant at the 5% level. When ordinary standard errors are used this series loses its apparent seasonality. However in all cases this series maintained an individual result for December significant at the 10% level or lower.

Together with the graphical evidence, this indicates a seasonal effect on the growth in credit card accounts for December. This makes some sense – we might not expect seasonality in the levels of credit card accounts whereas we might expect some December seasonality in the growth rate in credit card accounts. Unlike transaction levels people are not confronted each month with the decision to have a credit card account. Instead these are decisions made infrequently and last one or several years before requiring reconsideration. December is a time likely to inspire the need or desire for a new account.

We will assume seasonality for the differenced series due to a reasonable belief that opening new credit card accounts could easily be seasonal, the strong seasonality apparent for the series in December and the strong seasonality in the other series. Qualitative results were not sensitive to this assumption.

The credit card share of the total convenience payment market had indications of strong seasonality. Credit card share of the total convenience payment market also had a strong individual result for December, as might be expected due to the timing of Christmas and its impact on retail purchases.

Interestingly the credit card share of the total card market was also found to be seasonal although December did not show up as individually significantly different from January. Instead February was the individual month contributing most to seasonality, with an indication of higher credit card market share in this month. As the graph of this series had the least obvious trend of all the series we tested for seasonality without a time trend and got the same qualitative outcome – seasonality overall with February as the individual month differing most significantly from the January baseline. It is not immediately clear why this should be the case. This series is the one affected by the "sawtooth" pattern mentioned previously – perhaps there is a primary sampling artefact at play. In any case we will assume seasonality is important for this series and continue to treat results from this series with some caution.

The credit card share of the narrower credit and debit card market and of the credit and charge card market were both found to be highly seasonal. December did not show up as individually significantly different from January, with or without a time trend.

We considered the use of more complex seasonal adjustment involving moving averages. We chose not to do this as most such prefilters (Tramo/Seats, X-12-ARIMA etc) can distort the underlying properties of the data, adding a degree of autoregressive character that is not actually present. In particular, theory and Monte Carlo studies show that for linear models with a single structural break that seasonal adjustment such as X-11 smoothes data in such a way as to hide structural instability and reduce the probability of detecting a break (Ghysels & Perron, 1996). Further the sum of the autoregressive coefficients in a univariate regression with a stationary series has an upwards bias when common seasonal adjustment processes are used (Ghysels & Perron, 1993). This is due to the seasonal adjustment inducing a bias in the autocorrelation function at lags less than the seasonal period – a bias which does not vanish even asymptotically, even as underlying seasonality is eliminated. This upward bias tends to decrease the power of tests for a unit root, as shown for Dickey Fuller type tests by Ghysels and Perron (1993).

Table 2 Seasonality tests[a]

Series[b]	**Time trend p-value**	**Joint F-test on seasonal dummies[c] (p value)**	**December dummy t-test p value**	**Seasonal dummies used in regressions**
Log credval	0.000	66.2 (0.000)	0.000	✓
May 1994-Jun 2007	0.000	15.8 (0.000)	0.000	✓
Δ Log credval	0.620	32.6 (0.000)	0.000	✓
May 1994-Jun 2007	0.112	38.2 (0.000)	0.000	✓
Log credaccts	0.000	0.4 (0.970)	0.377	✗
May 1994-Jun 2007	0.000	0.5 (0.922)	0.147	✗
Δ Log credaccts	0.134	2.0 (0.048)	0.025	✓
May 1994-Jun 2007	0.673	6.3 (0.000)	0.016	✓
Credsharetotal	0.001	13.5 (0.000)	0.007	✓
Credsharecards	0.411	11.6 (0.000)	0.713	✓
Credsharecredeb	0.304	24.9 (0.000)	0.840	✓
May 1994-Jun 2007	0.053	3.5 (0.000)	0.649	✓
Credsharecredchar	0.001	20.6 (0.000)	0.169	✓

a OLS estimation; Newey West standard errors with 12 lags (Newey & West, 1987) used as testing using a 12 lag Breusch Godfrey LM test, via Stata module bgodfrey, indicated some serial correlation for all series (Breusch, 1978; Godfrey, 1978).

b All series include time trends. Where time trends were insignificant re-testing without time trends gave qualitatively unchanged results.

c January is the baseline month.

5. Unit root tests

Testing for a unit root is used to establish which series, if any, are suitable for Chow type tests for a structural break. We use an augmented Dickey Fuller test and a Dickey Fuller Generalised Least Squares test for a unit root. We also test for a unit root versus the alternative of a trend stationary process with a structural break.

5.1 ADF tests for a unit root

First we use an augmented Dickey Fuller (ADF) test for unit roots on the time series (Dickey & Fuller, 1981). Following the assumption of deterministic seasonality, we include seasonal dummy variables where applicable:

$$\Delta y_t = \alpha_1 + \sum_{i=2}^{12} \alpha_i M_{ti} + \delta t + \beta y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + \varepsilon_t, t = 1,...,T$$

M_{it} are centered seasonal dummies, used to avoid shifting the magnitude of the intercept, as suggested in Enders (2004). M_{it} = 11/12 if the month corresponds to the month i and -1/12 otherwise, with January as the base month.

The null hypothesis of this unit root test is $\beta = 0$, the variable has a unit root. The alternative hypothesis is $\beta < 0$ and there is no unit root. Instead the series is trend stationary, a stationary autoregressive process, potentially added to a deterministic time trend. The ADF tests are done with a deterministic trend and constant and with a constant alone. Dickey and Fuller (1979; , 1981) showed that the t-statistic for testing $\beta = 1$ has a non standard distribution and they provided Monte Carlo simulation critical values for various sample sizes. They also showed that the limiting distribution is unchanged by adding k lagged first differences to augment the model and account for serial correlation (Dickey & Fuller, 1981). The null hypothesis of a unit root can be tested with deterministic seasonality provided for by using seasonal dummy variables as Dickey, Bell and Miller (1986, p. 25) show that the limiting distribution for β is not affected by the removal of the deterministic seasonal components. Critical values are linearly interpolated from Fuller (1976).

In practice the lag length k is unknown. The final lag length is selected using the data dependent method of a sequential t-test. This method involves starting with some maximum number of lags selected *a priori*, then removing successive lags until a significant lag is found using a significance level of 10%. See Ng and Perron (1995) for further discussion on the theoretical justification for this procedure and Perron and Vogelsang (1992) for simulation results in the context of unit root tests with breaks. This procedure is liberal in the number of lagged first differences it tends to imply compared with using a 5 % significance level or an information criteria method such as Schwarz (1978) or Akaike (1974). We justify this because including extra lagged first differences provide tests of better size without much loss of power whereas using too few lags can greatly affect the size of the test (Ng & Perron, 1995).

Selection of the maximum lag length receives relatively little discussion in the literature. Hall (1994)used k_{max} = 24 for monthly data, Perron (1989)and Zivot and Andrews (1992) both use k_{max} = 8 for annual data and k_{max} = 12 for quarterly data. Clemente, Montanes and Reyes (1998) use k_{max} = 5 for mean shift work using quarterly data. None of these have given any particular justification for the selected k_{max}.

We have set maximum lag length according to $k_{\max} = \text{int}\left[12\{(T)/100\}^{0.25}\right]$. This is inspired by Schwert (1989) who had this as the largest lag length tested in his work on the effect of lag lengths. We prefer this longer specification of maximum lag length here as we are dealing with monthly data and it is unclear whether credit card transactions have longer term interactions. This maximum lag was also recommended by Ng and Perron (2001) in their work on alternative information criteria for Dickey Fuller Generalised Least Squares (DFGLS) tests and was also recommended by Harris (1992) on the basis of the size and power properties of the resulting ADF tests, based on tests of roughly similar sample size to this study.

The second ADF style test we pursue is the Dickey-Fuller Generalised Least Squares (DFGLS) test of a unit root. This test proposed by Elliot, Rothenberg and Stock (1996) is a modification of the augmented Dickey-Fuller t-test. The time series is transformed via a generalised least squares regression prior to performing the test. Elliott et al. and other subsequent studies have shown this test to have greater power than previous versions of the augmented Dickey-Fuller test.

The null hypothesis of the test is that y_t is a random walk, possibly with drift. There are two distinct possible alternative hypotheses for this test, with separate testing procedures. The first alternative hypothesis is y_t is stationary around a linear time trend. The second alternative hypothesis is y_t is stationary with no linear time trend.

Under the first alternative hypothesis, define the new variables:

$$\bar{y} = \left[y_1, (1-\alpha L)y_2, \ldots, (1-\alpha L)y_T\right]'$$

$$\bar{z} = \left[z_1, (1-\alpha L)z_2, \ldots, (1-\alpha L)z_T\right]'$$

With $\alpha = 1 + (\bar{c}/T)$, L as the lag operator, y_t as the original time series and z_t as $[1,t]'$. An ordinary least squares regression is estimated by regressing $\bar{y}$ on $\bar{z}$ obtaining the estimators $\hat{\beta}_0$ and $\hat{\beta}_1$. These estimators are used to remove the trend from y_t. That is we de-trend the series using:

$$y_t^d = y_t - \left(\hat{\beta}_0 + \hat{\beta}_1 t\right)$$

Finally the transformed variable is used in an augmented Dickey-Fuller test:

$$\Delta y_t^d = \theta y_{t-1}^d + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j}^d + \varepsilon_t$$

We test the null hypothesis $H_0 : \theta = 0$ using interpolated tabulated critical values by Elliot et al. (1996). We use $\bar{c} = 13.5$ as suggested by Elliot et al. (1996, p. 825).

For the second alternative hypothesis we proceed as above except we use $\bar{c} = 7$, z_t as $[1]'$ and de-trend using $y_t^d = y_t - \hat{\beta}_0$. The augmented Dickey-Fuller regression is fitted using the transformed variable and we test the null hypothesis $H_0 : \theta = 0$ using tabulated critical values by Elliot et al. (1996).

Both tests include 1 to k lags of the 1st difference, detrended variable. As for the augmented Dickey-Fuller tests we set k_{max} by the method described by Schwert (1989). Following the work of Ng and Perron 2001 in examining the DFGLS power and size properties we use a Modified Akaike Information Criteria (MAIC) to determine the final lag length. They showed this method to have superior size/power to the sequential t-test method for the DFGLS test. This method differs from the sequential t-test method used in the ADF tests, occasionally resulting in different lag length selection between the two tests.

If the null of a unit root is rejected we assume the series is stationary and can proceed to use a Chow type test to determine if there is a break in the series after October 2003.

Given the notoriously low power of ADF type tests we also perform tests for a unit root against a process with an exogenously determined structural break and no unit root, described in the following section.

5.2 Unit root versus structural break

Perron (1989) shows that standard unit root tests that don't allow for a structural break can have low power against the alternative of no unit root, when the underlying series has a structural break and no unit root. Accordingly if the null of a unit root is not rejected in the ADF tests we can use Perron's (1989) procedure to test for unit roots in the presence of structural change.

Perron's procedure tests the null hypothesis that a series has a unit root with drift and an exogenous structural break at time $1 < T_B < T$ versus the alternative hypothesis that the series is stationary around a deterministic time trend with an exogenous break at time T_B. Perron considered three models. Model A allows an exogenous change in the intercept of the series, Model B has an exogenous change in the trend only and Model C has an exogenous break in both the trend and intercept. The null hypotheses are:

$$H_0 : y_t = \mu + dD(T_B)_t + y_{t-1} + \varepsilon_t \qquad \text{Model A}$$

$$H_0 : y_t = \mu_1 + y_{t-1} + (\mu_2 - \mu_1)DU_t + \varepsilon_t \qquad \text{Model B}$$

$$H_0 : y_t = \mu_1 + y_{t-1} + dD(T_B)_t + (\mu_2 - \mu_1)DU_t + \varepsilon_t \qquad \text{Model C}$$

Where:

$D(T_B)_t = 1$ if $t = T_B + 1$ and zero otherwise; a pulse dummy variable.

$DU_t = 1$ if $t > T_B$ and zero otherwise; a level dummy variable.

The alternative hypotheses are trend stationary series with a change in the intercept, the slope of the trend or both:

$H_1 : y_t = \mu_1 + \beta t + (\mu_2 - \mu_1)DU_t + \varepsilon_t$ Model A

$H_1 : y_t = \mu_1 + \beta t + (\beta_2 - \beta_1)DT_t^* + \varepsilon_t$ Model B

$H_1 : y_t = \mu_1 + \beta t + (\mu_2 - \mu_1)DU_t + (\beta_2 - \beta_1)DT_t + \varepsilon_t$ Model C

Where

$DT_t^* = t - T_B$ if $t > T_B$ and zero otherwise.

$DT_t = t$ if $t > T_B$ and zero otherwise.

Where seasonality is indicated, seasonal dummy variables are included. We first estimate the regression H_1, then use the residuals $\hat{y}_t$ to estimate the regression:

$$\hat{y}_t = a_1 \hat{y}_{t-1} + \sum_{i=1}^{k} \beta_i \Delta \hat{y}_{t-i} + e_t$$

The t-statistic for the null hypothesis $a_1 = 1$ can be compared with the critical values for the models calculated by Perron (1989). The critical values vary with the proportion of the breakpoint to the entire sample, λ. Here the break point is exogenously given as October 2003, which approximately gives $\lambda \sim 0.2$ for the default series from January 2002 to June 2007 and gives $\lambda \sim 0.694$ for the extended series from May 1994 to June 2007 (accounting for observations lost due to lags).

5.3 Unit root test results

Table 3 shows the ADF unit root test results. Table 4 shows the results of the Perron test for a unit root versus a trend stationary process with a structural break. The ADF testing indicates most of the series are I(1) using the results of either the ADF tests or the DFGLS tests. That is we are unable to reject the null of a unit root at the 5% significance level using either test for most of the series.

The major exception to this is the differenced log credval series. The null hypothesis of a unit root in the log credval series is rejected under the ADF test using differenced data, implying there is not a second unit root. Given the notoriously low power of these types of tests we will view this as a rejection of the null of a unit root at the 5% significance level even thought e DF-GLS test failed to reject the unit root null. So the log level series appears to be I(1). Tests on the extended credit card purchase series could not reject the null of a unit root in either levels or differences. This implies the series is at least I(2) or is subject to a break or breaks.

For credit card accounts, the levels series results failed to reject the null of a unit root. The differenced series also failed to reject the null of a unit root in these tests. This may be due to its seasonality being dominated by the single month of December[4]. The extended differenced series did reject the null of a unit root, but only at the 10% significance level. As this does not satisfy the conventional 5% significance level we do not immediately pursue Chow type testing for this series. However we do note that this may indicate some long term stability in the growth rate of credit card accounts.

The market shares are bound by construction and so would be expected to be stationary in the long run. The results indicate the share of the credit and debit market for the extended series to be stationary without trend at the 10% level, using the DFGLS test. However the tests of share of the total convenience payment market fail to reject the null hypothesis of a unit root. Indeed similar tests on credit cards as a share of the total card market and even as a share of credit and charge cards also failed to reject the null of a unit root.[5]

This apparent lack of stationarity in the credit card market shares may be due to the noticeable “sawtooth” pattern in some of these series. It may also be the result of a large structural break. However the Perron test of an exogenous break at the time of the credit card reforms also failed to reject the null of a unit root for these series.

The Perron tests all failed to reject the null of a unit root at the 5% level except for the shorter Δ Log credval series which was already found to be stationary using ADF tests.

These results suggest we should treat log credval as difference stationary with a deterministic trend. We do so in the Chow type tests for an exogenous structural break in the next section. The other series are not tested with a Chow type test for an exogenous structural break due to stationarity concerns.

---

[4] However tests excluding seasonality still failed to reject the null of a unit root.

[5] Differencing the series removed the unit root in some cases but the interpretation of the resulting series is problematic - we would be looking for breaks in the marginal effects of variables causing a change in credit card share.

Table 3 Unit root test results

Series, deterministic regressors[a]	ADF			DFGLS		
	Lags	Test stat	5% CV	Lags	Test stat	5% CV
Log credval						
Trend & constant	8	-1.581	-3.495	8	-1.264	-3.14
Constant	8	-1.354	-2.926	10	1.176	-1.95
May 1994-Jun 2007						
Trend & constant	12	-1.034	-3.444	13	-0.918	-2.97
Constant	12	-2.408	-2.887	13	0.064	-1.95
Δ Log credval						
Trend & constant	7	-4.259***	-3.495	9	-1.690	-3.14
Constant	7	-4.083***	-2.926	9	-0.725	-1.95
May 1994-Jun 2007						
Trend & constant	11	-2.698	-3.444	13	-2.247	-2.97
Constant	11	-1.714	-2.887	13	-0.865	-1.95
Log credaccts						
Trend & constant	8	-2.352	-3.495	1	-1.049	-3.14
Constant	8	0.389	-2.926	3	0.240	-1.95
May 1994-Jun 2007						
Trend & constant	12	-2.618	-3.444	3	-1.840	-2.97
Constant	7	-0.593	-2.887	9	0.764	-1.95
Δ Log credaccts						
Trend & constant	7	-1.986	-3.495	4	-1.972	-3.14
Constant	7	-2.045	-2.926	8	-1.289	-1.95
May 1994-Jun 2007						
Trend & constant	6	-2.737	-3.444	7	-2.433	-2.97
Constant	6	-2.746*	-2.887	7	-1.882*	-1.95
Credsharetotal						
Trend & constant	2	-1.144	-3.495	2	-0.932	-3.14
Constant	2	-1.898	-2.926	2	-0.389	-1.95
Credsharecards						
Trend & constant	8	-1.987	-3.495	8	-1.213	-3.14
Constant	8	-1.875	-2.926	8	-0.472	-1.95
Credsharecreddeb						
Trend & constant	8	-1.619	-3.495	8	-1.204	-3.14
Constant	8	-1.035	-2.926	8	-1.038	-1.95
May 1994-Jun 2007						
Trend & constant	12	-2.160	-3.444	9	-1.876	-2.97
Constant	12	-2.094	-2.887	9	-1.801*	-1.95
Credsharecredchar						
Trend & constant	8	-2.390	-3.495	2	-1.420	-3.14
Constant	8	-1.847	-2.926	10	-0.241	-1.95

***, **, * indicate significance at 1%, 5% and 10% level respectively.

a All series include seasonal dummies except for the two log credaccts series.

Table 4 Unit root versus structural break test results

	Perron Model					
	A Intercept		B Trend		C Intercept & trend	
Series[a]	**Lags[b]**	**Test statistic[c]**	**Lags[b]**	**Test statistic[c]**	**Lags[b]**	**Test statistic[c]**
Log credval	8	-1.93	8	-2.65	8	-2.53
May 1994-Jun 2007	12	-1.99	12	-2.36	12	-2.38
Δ Log credval	7	-4.13**	7	-4.52***	7	-4.01**
May 1994-Jun 2007	11	-2.53	11	-2.49	11	-2.57
Log credaccts	1	-3.34	9	-2.04	7	-3.70*
May 1994-Jun 2007	12	-2.65	12	-2.52	3	-2.20
Δ Log credaccts	7	-3.37	7	-3.25	7	-3.34
May 1994-Jun 2007	6	-3.60*	6	-3.20	6	-3.60
Credsharetotal	9	-2.20	9	-2.99	9	-2.92
Credsharecards	8	-1.63	8	-1.69	8	-2.07
Credsharecreddeb	8	-1.70	8	-2.09	8	-2.12
May 1994-Jun 2007	12	-2.94	12	-2.71	12	-2.96
Credsharecredchar	9	-2.54	9	-2.49	9	-1.56

***, **, * indicate significance at 1%, 5% and 10% level respectively.

a All series include seasonal dummies except for the two log credaccts series.

b Perron lag lengths are determined using t-tests on the coefficients. Maximum lag length was as for ADF and GLS. The final value of k was selected if the t-statistic on β_k was greater than 1.60 in absolute value and the t statistic on β_i for i>k was less than 1.60 (Perron, 1989).

c Significance levels tested against interpolated critical values for each model given by Perron, with $\lambda \sim 0.2$ for the shorter series and $\lambda \sim 0.694$ for the extended series. For the shorter series the 5% critical values are -3.77, -3.80 and -3.99 for Models A, B and C respectively. For the longer series the 5% critical values are -3.798, -3.856 and -4.184 for Models A, B and C respectively.

6. Testing for an exogenous structural break

6.1 Binary variable interaction regression

For stationary series, we can use a Chow type test with dummy variables to test for a structural break in the time series data. Our primary tests assume the date of structural break is exogenously given as 31 October 2003, when the interchange fee was cut. We test for a statistically significant structural break at this time using:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_0 X_t + \gamma_0 D_L + \gamma_1 \left[D_L * Y_{t-1} \right] + \gamma_2 \left[D_L * X_t \right]$$
$$+ \theta_2 M_{2t} + \cdots + \theta_{12} M_{12t} + u_t$$

We test the null hypothesis of no structural break using this binary variable interaction regression. The full model consists of an intercept, the independent variable X and a single lag of the dependent Y variable. M_{it} are centered dummy variables for each month. The base month is January, $M_{2t} = 1$ for February and 0 for all other months, $M_{3t} = 1$ for March and 0 for all other months etc. D_L is a dummy variable that equals 0 before the interchange fee was changed on 31 Oct 2003 and equals 1 after that date.

Under the null hypothesis of no break:

$$H_0 : \gamma_0 = \gamma_1 = \gamma_2 = 0 .$$

Under the alternative there is a break and at least one of the γ is not zero.

The change in the general interest rate level is included as an independent variable via the proxy of changes to the RBA cash rate. Merchant fee levels and changes in merchant fee levels are not included in the regressions despite being of interest. Merchant fee levels are only available on the RBA website from March 2003 so there are not enough data points available prior to November 2003 to include this variable. We condition the Δ Log credval series on the change in log of real household final consumption.

We test both with and without a deterministic time trend for the Δ Log credval series. Diagnostic testing indicated using stata module bgodfrey with up to 12 lags indicated serial correlation so we used Newey West standard errors with 12 lags.

6.2 Results

Results from the structural break tests are given in Table 4. The regression excluding a time trend is slightly preferred due to its slightly higher adjusted R^2 and the time trend being insignificant at the 5% level. It is possible that alternative modelling strategies could uncover different processes. However, *the results here provide no support for an October 2003 break point negatively affecting the credit card series tested*.

We found no statistically significant evidence of an October 2003 structural break in the Δ Log credval series when conditioned on interest rate changes and real household consumption expenditure. The interpretation of this is there was no change in the use of credit cards relative to consumption. The tests give no evidence consistent with the claim that lowering the interchange fee would negatively affect the growth in the value of credit card transactions. The coefficient on the intercept dummy is negative but not significant at the 5% level.

The interest rate results indicated that growth in credit card transaction value was negatively related to interest rate changes. That is, increases in interest rates do tend to have a dampening effect on credit card purchase value. This may indicate that when interest rate rises occur some consumers switch where possible to other lower cost payment methods – instruments where the cost of use is less affected by interest rates.

After the break point this interest rate effect appears dampened as the interacted variable has the opposite sign and is significant at the 5% level. A possible explanation is due to the fact that interest rates have only risen over the January 2002 to June 2007 timeframe. It may be that at lower interest rates, an increase in interest rates causes a decrease in the growth of credit card purchases. Those who can access other forms of credit do so and people cut back on some discretionary expenditure. At higher interest rates any further increase in interest rates may leave more people with fewer choices for alternative credit sources or for cutting back expenditure. In this case less substitution away from credit cards occurs.

This possible reduction of the interest rate effect may also be due to the proliferation of competing credit cards following the loosening of the credit card access conditions. If competition increased then perhaps after the reforms credit card interest rates did not rise as quickly after cash interest rate rises. This remains an area to watch for the future.

The strong negative coefficient on the lagged value is some evidence of a mean reverting process. Strong growth in one month tends to be followed by weaker growth the next month and vice versa. Alternatively this could be a sampling artefact of some kind, dependent on how the RBA surveys each bank and association each month.

Table 5 Exogenous break point test results

Coefficient (p value)	Δ Log credval	Δ Log credval
Newey West lags[a]	12	12
Intercept dummy (D_L)	-0.0357 (0.090)	-0.0117 (0.111)
Lag (Y_{t-1})	-0.631 (0.000)	-0.640 (0.000)
Lag interaction ($D_L * Y_{t-1}$)	0.051 (0.771)	0.054 (0.757)
Time (T)	-0.0011 (0.310)	
Time interaction (D_T)	0.0014 (0.209)	
ΔInterest	-0.262 (0.015)	-0.214 (0.017)
ΔInterest interaction (ΔInterest * D_T)	0.354 (0.042)	0.307 (0.040)
Δ Logconsump[b]	2.69 (0.089)	1.89 (0.265)
Δ Logconsump interaction (Δ Logconsump * D_T)	-1.53 (0.143)	-1.53 (0.102)
Joint seasonal dummies significant?	✓	✓
F test of break slope dummies	2.27 (0.078)	3.33 (0.028)
F test of break dummies	2.19 (0.073)	2.62 (0.048)
R^2	0.7866	0.7853
Adjusted R^2	0.6873	0.6995
N	64	64

a OLS regression with 12 lag Newey West (1987) standard errors used as testing using the Stata bgodfrey module rejected the null of no serial correlation with 12 lags at the 5% significance level.

b Quarterly data for real household consumption expenditure, linearly interpolated to provide monthly figures. Results for June 2007 quarter were unavailable, March quarter results were used instead. Data source is the Australian Bureau of Statistics (2007a)

7. Tests with a single endogenously determined break

7.1 Approach

The previous sections assumed that the date of the structural break was exogenous and known to be October 2003. In this section we present test results from using the sequential test of Zivot and Andrews (1992) to endogenise the break point.

The null hypothesis of all of the unit root tests proposed by Zivot and Andrews is a unit root process with drift that excludes exogenous structural change.

$$H_0 : y_t = \mu + y_{t-1} + \varepsilon_t$$

The alternative hypothesis is a trend stationary process that allows for a one time break in the level, the trend or both. The break occurs at an unknown point in time.

Test A has the alternative hypothesis of a break in the intercept only. Test B has the alternative hypothesis of a break in the trend only. Test C has the alternative hypothesis of a single break in both the trend and the intercept:

$$H_1 : y_t = \mu + \beta t + \theta DL_t(\lambda) + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad \text{A}$$

$$H_1 : y_t = \mu + \beta t + \gamma DT_t(\lambda) + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad \text{B}$$

$$H_1 : y_t = \mu + \beta t + \theta DL_t(\lambda) + \gamma DT_t(\lambda) + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad \text{C}$$

Where:

$DL_t(\lambda)$ is a level dummy variable such that $DL_t(\lambda) = 1$ if $t > T\lambda$ and zero otherwise;

$DT_t(\lambda) = t - T\lambda$ if $t > T\lambda$ and zero otherwise.[6]

λ is the break fraction, chosen to minimise the one-sided t-statistic for testing $\alpha^i = 1$ (i = A, B, C), with small values of the statistic leading to rejection of the null. Typically the ends of the series are trimmed as the presence of the end points causes the asymptotic distribution of the statistics to diverge to infinity. We followed Zivot and Andrews and used the largest window possible, after allowing for lags and avoiding endpoints. So for j = k+2,..., T-1 we set the potential break fractions at λ=j/T.

---

[6] Note this is a slightly different arrangement and notation to the original Perron (1989) model this was derived from. Zivot and Andrews (1992) chose to set $DT_t = t - T\lambda$ for Model C rather than $= t$ as in the original Perron paper. This has the effect of shifting the pre break point intercept but leaves all other results equivalent.

Zivot and Andrews select the break point, λ, for the dummy variables in Perron's models A, B, C as the result of a regression method designed to have y_t fit a trend stationary process representation. This contrasts with Perron having the breakpoint as exogenous. So here the assumption is that the break point is unknown before testing and the test itself estimates the break point to be where the ADF unit root t-test statistic is minimised (i.e. the most negative). So the selection of the break point λ is endogenised and selected to give the least favourable result to the null and to maximise the weight given to the trend stationary alternative.

Selecting a particular model for a series is not straightforward. Some authors select Model C on the basis that it is the most general. However differenced log series are effectively growth rates and so are less likely to trend in the longer run. So instead we do not impose a particular model and instead will interpret the results collectively. We do note that allowing for an intercept change will tend to capture immediate effects while a shift in the trend function will tend to capture more gradual change.

Lags are used to correct for serial correlation. In estimating the test regression a data dependent procedure is used to find the optimal number of lags to include. As for the previous ADF tests we use a general to specific routine, choosing the number of lags k so that the coefficient on the last included lagged difference is significant at the 10% level, yet is insignificant for larger lags, up to the maximum lag length k_{max}. This sequential procedure can cause some loss of power due to excess parameters, however information criteria methods were found to give models that are too parsimonious and give severe size distortions (Ng & Perron, 1995). We have used maximum lag length $k_{\max} = \text{int}\left[12\{(T)/100\}^{0.25}\right]$, as per the previous ADF and DFGLS tests.[7]

In searching for the break date in this Zivot Andrews test we use an individually selected value of k, the number of lags, for every potential break date.

There is no off the shelf module for performing this calculation in Stata. There is a commonly used user written Stata module available for this test, zandrews. It has two critical inconsistencies with the procedure put forward by Zivot and Andrews. Firstly it only selects a single value for the lag length k, computed based on no structural break in the series. The zandrews module then uses this value of k at all potential break dates. This is not the procedure followed by Zivot and Andrews.

The second apparent inconsistency is that the zandrews module appears to have the break in any time trend or intercept starting one period earlier than Zivot and Andrews have. Zivot and Andrews have $DL_t(\lambda)$ is a level dummy variable such that $DL_t(\lambda)=1$ if $t > T\lambda$ and zero otherwise; $DT_t(\lambda)=t-T\lambda$ if $t > T\lambda$ and zero otherwise. The zandrews module appears to have $DL_t(\lambda)=1$ if $t \geq T\lambda$ and zero otherwise; $DT_t(\lambda)=t-T\lambda$ if $t \geq T\lambda$ and zero otherwise. This leads to incorrect identification of the break point.

---

[7] Using a longer maximum lag length is also conservative for this study. This is because any selection of longer lags as a result of using a larger maximum lag reduces the number of time periods at the start of the sample that are available to be selected as break points. Eliminating these potential break points means the time of the credit card reforms faces less competition to be selected as the break point.

As a result I wrote new Stata modules to perform the Zivot Andrews tests using the correct lag selection procedure and correct interpretation of the break dates. A copy of the code for the case where there is a break in both the intercept and trend is included as an Appendix.

Where seasonality was indicated this test was done on deseasonalised data, using the residuals $\hat{y}_t$ from the regression:

$$y_t = \partial_1 + \sum_{i=2}^{12} \theta_i M_{it} + \varepsilon_t$$

Where M_{it} are centered dummy variables for each month, January is the baseline.

These residuals are used in the underlying ADF unit root tests.

The null is rejected if $\alpha = 1$ is rejected using the asymptotic distributions provided by Zivot and Andrews (1992). The test is constructed differently and so has a different sampling distribution to that of Perron. The critical values tend to be larger. Of course this is offset by the endogenisation of the breakpoint – the selection of the breakpoint so as to maximise the weight of the trend stationary alternative.

7.2 Results

We present results in Table 6 for Zivot Andrews tests incorporating an endogenous break in the intercept, the trend or a break in both the intercept and trend. Consistent with the interpretation of Zivot and Andrews the dates given are the last month of the initial regime. Results in bold indicate that the null of a unit root process with drift and no structural break was rejected at the 5% significance level.

The series generally do not suggest October 2003 as a break point and in fact none of the significant structural breaks are even close to October 2003. Instead other dates feature, particularly around the time of interest rate changes, the introduction of the Goods and Services Tax (GST) in July 2000 and the change in reporting methodology in January 2002. These are discussed below for the individual series.

The Log credval levels series had a significant negative break in intercept and trend in February 2005, probably associated with the interest rate rise of March 2005. The results for Δ Log credval suggest a trend stationary process with a one time break in the trend, intercept or both. December 2006, May 2005 and August 2004 feature as significant negative break dates. There is no reason *a priori* to necessarily expect them to have the same date as they incorporate different assumptions about the short and long term effects of the structural break. These results are quite separated from the date of the major reforms.

The credit card share of the total convenience payment market suggests similar significant negative break dates of September 2004 for Model B, break in trend and August 2004 for Model C, break in trend and intercept. There is no clear explanation for either of these dates. They are well after the change in interchange fees. It may be that this particular series is affected more by movements in the other components, such as personal checks, than in movements in the underlying credit cards series.

The Δ.Log credaccts series had some suggestion of a potential **positive** break around September and October 2003. These were not strong enough to reject the null of a unit root however.

As anticipated, December 2001 is an endogenously selected break date for several of the various extended series. This was the time of the change in data collection methodology by the RBA. The introduction of the Goods and Services Tax (GST) in June 2000 coincides with a significant negative structural break in the intercept and trend in the extended Δ Logcredval series. This represents a significant structural break in the growth rate of credit cards purchases. May 2000 was also the endogenously selected trend break point for the credit card market share of the extended combined credit and debit card market, although it was not statistically significant.

The extended series also featured dates associated with one or more interest rate changes. There was a positive significant break in the extended Δ Logcredval in March 1997 and there was a positive, albeit not significant, break point indicated in April 1997 for the level series. This was probably associated with two 0.5% interest rate cuts in the following months.

Testing the credit card share of the total cards market, the narrower credit and debit cards market and the credit and charge cards market all failed to reject the null of a unit root at the 5% level for each of the Zivot Andrews models. A similar result holds for the shorter log credval and log credaccts series in levels. This is evidence against a structural break for these series.

These endogenous single break point tests do not provide support for an October 2003 break point negatively affecting the credit card series tested. They are potentially suggestive of multiple break points. The plots of the Zivot Andrews results, not reproduced here, also indicate the potential for multiple break points in some of the series. Further work using tests for two break points is developed in the next section.

Table 6 Zivot Andrews unit root tests

Estimated breakpoint and direction of break
t-statistic

Series[a]	**Intercept (Model A)**	**Trend (Model B)**	**Intercept & trend (Model C)**
Logcredval	Apr 2005 ↓* -3.24	Jun 2004 ↓* -3.60	Feb 2004 ↑*↓* -3.90
May 1994-Jun 2007	Apr 1997 ↑* -3.06	**Dec 1999** ↓* **-6.74*****	**Feb 1999** ↑ ↓* **-5.21****
Δ Logcredval	**Dec 2006** ↓* **-5.77*****	**May 2005** ↑* **-5.41*****	**Aug 2004** ↓ ↑ **-5.56****
May 1994-Jun 2007	**Mar 1997** ↑* **-4.96****	Sep 1997 ↓* -3.82	**Jun 2000** ↓*↓* **-6.02*****
Log credaccts	Mar 2003 ↓* -3.37	Jan 2003 ↑* -3.70	Mar 2003 ↓ ↑ -3.40
May 1994-Jun 2007	**Dec 2001** ↓* **-8.00*****	Sep 2004 ↑ -2.76	**Dec 2001** ↓*↑* **-9.68*****
Δ Log credaccts	Jun 2006 ↓* -4.25	Sep 2005 ↓* -4.24*	Oct 2003 ↑*↓ -4.16
May 1994-Jun 2007	Sep 2003 ↑* -3.98	Jan 2002 ↑ -3.58	May 2001 ↓*↑* -4.19
Credsharetotal	Dec 2003 ↑* -3.27	**Sep 2004** ↓* **-5.45*****	**Aug 2004** ↓ ↓* **-5.48****
Credsharecards	Mar 2005 ↓* -3.36	Mar 2003 ↓ -2.59	Mar 2005 ↓*↑ -2.73
Credsharecreddeb	Apr 2005 ↓* -4.33	Jul 2003 ↓ -2.34	Apr 2005 ↓*↓ -3.42
May 1994-Jun 2007	Dec 1998 ↑* -4.01	May 2000 ↓* -3.60	**Dec 2001** ↓*↓* **-5.32****
Credsharecredchar	Mar 2004 ↓* -4.15	May 2005 ↑ -3.94	Mar 2005 ↓ ↑ -4.17

***, **, * indicate significant at 1%, 5% and 10% level respectively. Series in bold reject the unit root null at the 5% level in favour of a break in the series. Critical values from Zivot and Andrews (1992). Model A critical values are -5.34, -4.80 and -4.58 for the 1, 5 and 10% significance levels respectively. Model B critical values are -4.93, -4.42 and -4.11 similarly. Model C critical values are -5.57, -5.08 and -4.82 similarly.

Arrows indicate the direction of the break. * on the arrow indicates that the coefficient was significant at the 5% level. This is not reliable where the unit root null is not rejected.

a All series are deseasonalised with dummy variables except for both Log credaccts series.

8. Tests with two endogenously determined breaks

8.1 Approach

The Zivot and Andrews (1992) test can suffer from low power in the presence of two (or more) structural breaks in the series (Lumsdaine & Papell, 1997). In particular, it has been pointed out that "just as failure to allow one break can cause non-rejection of the unit root null by the Augmented Dickey-Fuller test, failure to allow for two breaks, if they exist, can cause non-rejection of the unit root null by the tests which only incorporate one break" (Ben-David et al., 2003, p. 304).

We maintain that the October 2003 break date we used in the exogenous tests is the one where the credit card reforms were most direct and significant. However it is possible that the announcements of the reforms and other events may have also caused significant break points. For example the Zivot Andrews tests in the previous section for the extended series showed significant break points for some series at the time of the data collection changes from December 2001 to January 2002. These could be masking other potential breakpoints. Accordingly we extend our testing to cover the possibility of two structural breaks

We apply the tests from Lumsdaine and Papell (1997), which extend Zivot and Andrews model A and model C to allow for two structural breaks. Lumsdaine and Papell call these models AA and CC respectively, with model AA allowing for two breaks in the intercept of the trend and model CC allowing for two breaks in the intercept and slope of the trend. They also develop a model with one break in the intercept and trend and one break in the intercept only, Model CA.

The concept is quite analogous to the Zivot Andrews test. The model setting is:

$$y_t = \mu + \beta t + \theta_1 DU1_t + \gamma DT1_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad \text{AA}$$

$$y_t = \mu + \beta t + \theta_1 DU1_t + \gamma DT1_t + \theta_2 DU2_t + \gamma_2 DT2_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad \text{CC}$$

$$y_t = \mu + \beta t + \theta_1 DU1_t + \gamma DT1_t + \theta_2 DU2_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad \text{CA}$$

Where the dummies capturing changes in the intercept are:

$DU1_t = 1$ if $t > TB1$ and zero otherwise; $DU2_t = 1$ if $t > TB2$ and zero otherwise

The dummies capturing changes in the trend are:

$DT1_t = t - TB1$ if $t > TB1$ and zero otherwise; $DT2_t = t - TB2$ if $t > TB2$ and zero otherwise.

Analogously to the Zivot Andrews tests the two structural breaks $TB1$ and $TB2$ are searched for over the range k+2/T to (T-1)/T. The two breaks are kept from being too close to each other by imposing $TB2 > TB1 + 1$ for model for CC and AA and imposing $TB2 \neq TB1 \pm 1$ for Model CA. Lagged differences are included as per the Zivot Andrews test of the previous section.

The null hypothesis is a unit root process without a structural break, $\alpha = 1$, and the alternative is stationarity with two structural breaks. Model AA has two breaks in the intercept but not the slope of the trend function, Model CC allows two breaks in the intercept and in the trend function and Model CA allows one break in the intercept and trend function and one break in the intercept alone.

In searching for the break dates in this test we use an individually selected value of k, the number of lags, for every potential pair of break dates.

There is no off the shelf module for performing this calculation in Stata. As a result I wrote new Stata modules to perform the model CC, AA and CA tests. A copy of the code for model CC where there are two breaks in the intercept and trend is included as an Appendix.

Where seasonality was indicated this test was done on deseasonalised data, using the residuals $\hat{y}_t$ from the regression:

$$y_t = \partial_1 + \sum_{i=2}^{12} \theta_i M_{it} + \varepsilon_t$$

Where M_{it} are centered dummy variables for each month, January is the base.

These residuals are used in the underlying ADF unit root tests.

The null is rejected if $\alpha = 1$ is rejected using updated critical values (Ben-David et al., 2003). They note that allowing for more breaks does not necessarily mean more rejections of the unit root null hypothesis. This is because the critical values increase with the number of breaks.

8.2 Results

We present results of Lumsdaine and Papell tests for two endogenously determined structural breaks versus the null of a unit root with no structural break in Table 7. As for the Zivot and Andrews tests results most series do not feature significant negative break points even close to October 2003. Also as before the extended series tend to indicate a December 2001 break associated with the change in RBA data collection

The credval series does not feature a break point at October 2003, significant or insignificant, in log levels or in growth rates. Several significant breaks are instead associated with interest rate changes and the introduction of the Goods and Service Tax. The interest rate cuts in May and July 1997, following close on the heels of two previous interest rate cuts towards the end of 1996, can be linked with strongly positive significant break points in the Δ Log credval series at March, April and August 1997. This implies a positive break in the growth rate of the credval series at around this time. Because each model includes different assumptions about how the break occurs the dates need not match exactly. However this is indicative of an upswing in usage around this time.

The introduction of the Goods and Service Tax in July 2000 is linked to the strongly negative significant break points in the extended Δ Log credval series for all models.

The log levels series also features dates associated with interest rate changes, although the models do not always reject the null hypothesis of a unit root. For example April 2005 has a negative break point, albeit insignificant, following the interest rate rise of the previous month. Following the interest rate rise of December 2003, January 2004 appears to have a break implying a slight positive spike in its intercept and negative trend thereafter. This is a significant break in Model CA.

December 2006 appears as a positive break in the Δ Log credval series, despite following an interest rate rise in November 2006. Normally we might expect interest rate rises to dampen credit card usage. However it is plausible that a significant number of people lose access to cheaper forms of credit as interest rates rise. People may have maintained their holiday season spending plans in the short term by using credit cards.

Allowing for multiple breaks has uncovered some support for a break around at October 2003 in the Δ Log credaccts series. The shorter series here appears to be associated with a strong **positive** change to the intercept term, indicating an increase in the credit card account growth rate. A positive break in the intercept around this time was indicated in all three models, with Models AA and CA both rejecting the null of a unit root at the 5% level.

It would appear that the credit card reforms may have caused the banks to change some of the features of their cards, such as the rewards components and annual fees on cards. Card users have responded by starting new accounts, selecting among the changed offerings. This has led to a short term increase in the account growth rate, as people start new accounts but don’t necessarily immediately close their existing accounts, causing a spike in the credit card account growth rate.

Simple Chow type tests on the Δ Log credaccts series using an October 2003 break point were performed and are reported in Table 8. Results including a deterministic time trend found a strongly significant **positive** change to the intercept term, indicating an increase in the average credit card account growth rate, all other variables held constant. The results for the time trend suggest that prior to the break point the growth rate itself was increasing slowly over time. However after the break point the trend change in the growth rate itself has essentially become zero.

Increases in interest rates spur statistically significant increases in credit card account growth rates. One could speculate that this indicates a proportion of consumers use a new credit card account to ease cash flow concerns in the aftermath of interest rate rises. The negative coefficient on the interaction term for this indicates a reduction in this effect since the break point. Banks have increased the fees associated with cards to offset the decline in interchange revenue. As the fixed costs of having an account have increased it now costs more to obtain credit simply by opening a new account. This may have contributed to the decrease in the interest rate effect.

The credit card market share of the total convenience payment market rejected the null hypothesis of a unit root at the 5% level for Model CC, breaks in both intercept and trend, and Model CA, break in trend and intercept and break in intercept. May 2003 appears in Model CC and July 2003 appears in Model CA.

Although the interchange fee standard came into force in July 2003 the actual change in the interchange fee did not occur until 31 October 2003. There may have been some anticipation of the reforms and it is possible the issuing banks were not promoting credit cards as heavily while awaiting the outcome of their failed Federal Court challenge to aspects of the reforms. More significantly January 2004 saw strong **positive** significant breaks in Model CC. This was just after the start of the reforms and at the time of consecutive interest rate rises in November 2003 and December 2003. Credit card market share of the total convenience payment market appears unharmed by the reforms, even when accompanied by successive interest rate rises.

In the cards market the null of a unit root could not be rejected using any of the models. Debit and charge cards are relatively close substitutes for credit cards and so this might have been a series where a break would be seen as most likely at the time of the reforms. It turns out that August 2003 is one of the endogenously selected break points for model CC, with a negative impact implied for the trend function. However the null of a unit root is not rejected at the 5% significance level. There may have been some turbulence in this market at that time as people shifted between different cards as the card offerings of the issuing banks changed in response to the reforms. Interestingly this market also had an insignificant break point at May 2003, the time of market entry of Virgin credit cards, with an intercept spike but a trend decline.

In the more narrowly defined credit and debit cards market (from January 2002 to June 2007) and credit and charge cards market the null of a unit root could not be rejected at the 5% level using any of the models. Interestingly March 2004 is selected as a break date here in Model AA, breaks in intercepts only and in Zivot Andrews Model A, break in intercept only, albeit while not significantly rejecting the null of a unit root. It is a negative break in the intercept in each case and occurs a number of months after the reforms. It coincides with an apparent break noted during the inspection of the time series plot Figure 6, Section 4.2. There was a shift of ~1.1%

from credit cards to charge cards such as American Express and Diners Club from March 2004 to May 2004. Given the similarity of these instruments we would have expected some change due to the significant price change associated with the reforms. However the graphical analysis and the failure to reject the unit root null suggest an impact that shifted market shares only slightly, a number of months after the reforms. Any shift appears to have been neither dramatic or the start of a sustained trend. We do not recognise it as a genuine break in the series.

May 2003 and June 2003 are interesting break dates that occur in several series, albeit not always significant at the 5% level. These tend to be associated with positive intercepts. Virgin made a highly publicised entry to the Australian credit card market in this month, which appears to have created a spike in credit card usage at this time (Virgin Money, 2003).

The importance of interest rate changes is apparent from these results. Several breaks, significant and insignificant, can be directly linked with changes in interest rate levels. However there is little evidence for the credit card reforms affecting these series except for an increase in the intercept in the credit card account growth rate series.

Table 7 Lumsdaine and Papell unit root tests

Series	Estimated breakpoints TB1, TB2, direction of break in intercept then trend, t-statistic		
	Model CC	**Model AA**	**Model CA**
Logcredval	Aug 2003 $\uparrow \downarrow^{*}$ Apr 2005 $\downarrow^{*}\downarrow$ -6.51^{*}	May 2003 $\uparrow^{*}$ Jan 2004 $\uparrow$ -5.48	**Jan 2004** $\uparrow^{*}\downarrow^{*}$ **Jan 2007** $\uparrow^{*}$ $\mathbf{-6.95}^{**}$
May 1994-Jun 2007	**Apr 1997** $\uparrow^{*}\uparrow^{*}$ **Jun 1999** $\uparrow^{*}\downarrow^{*}$ $\mathbf{-8.04}^{***}$	Apr 1997 $\uparrow^{*}$ Jun 1998 $\uparrow^{*}$ -5.05	**Jun 1999** $\uparrow^{*}\downarrow^{*}$ **Aug 1997** $\uparrow^{*}$ $\mathbf{-7.03}^{**}$
Δ Logcredval	Jun 2003 $\uparrow^{*}\uparrow$ Sep 2005 $\uparrow \uparrow^{*}$ -6.40	**Sep 2005** $\uparrow^{*}$ **Dec 2006** $\uparrow^{*}$ $\mathbf{-6.39}^{**}$	Jun 2003 $\uparrow^{*}\uparrow$ Dec 2006 $\uparrow^{*}$ -6.15
May 1994-Jun 2007	**Mar 1997** $\uparrow^{*}\downarrow$ **Jun 2000** $\downarrow^{*}\downarrow$ $\mathbf{-8.32}^{***}$	**Mar 1997** $\uparrow^{*}$ **Jun 2000** $\downarrow^{*}$ $\mathbf{-8.47}^{***}$	**Jun 2000** $\downarrow^{*}\downarrow$ **Mar 1997** $\uparrow^{*}$ $\mathbf{-8.41}^{***}$
Log credaccts	Mar 2003 $\downarrow \uparrow$ Jul 2006 $\downarrow \downarrow^{*}$ -4.79	Mar 2003 $\downarrow^{*}$ Dec 2003 $\downarrow^{*}$ -4.74	Mar 2003 $\downarrow \uparrow^{*}$ Dec 2003 $\downarrow^{*}$ -5.49
May 1994-Jun 2007	**Feb 2000** $\uparrow^{*}\downarrow^{*}$ **Dec 2001** $\downarrow^{*}\uparrow^{*}$ $\mathbf{-12.0}^{***}$	**Dec 2001** $\downarrow^{*}$ **Mar 2005** $\uparrow^{*}$ $\mathbf{-11.0}^{***}$	**Dec 2001** $\downarrow^{*}\uparrow^{*}$ **May 2001** $\downarrow^{*}$ $\mathbf{-12.0}^{***}$
Δ.Log credaccts	Oct 2003 $\uparrow^{*}\downarrow$ Feb 2006 $\uparrow^{*}\downarrow^{*}$ -6.41	**Oct 2003** $\uparrow^{*}$ **Oct 2006** $\downarrow^{*}$ $\mathbf{-6.97}^{***}$	**Oct 2003** $\uparrow^{*}\downarrow$ **Oct 2006** $\downarrow^{*}$ $\mathbf{-6.88}^{**}$
May 1994-Jun 2007	**Dec 2001** $\downarrow^{*}\uparrow^{*}$ **Dec 2002** $\downarrow \downarrow^{*}$ $\mathbf{-9.43}^{***}$	**Dec 2001** $\downarrow^{*}$ **May 2002** $\uparrow^{*}$ $\mathbf{-7.23}^{***}$	**Dec 2001** $\downarrow^{*}\uparrow$ **May 2002** $\uparrow^{*}$ $\mathbf{-7.21}^{***}$
Credsharetotal	**May 2003** $\uparrow \downarrow^{*}$ **Jan 2004** $\uparrow^{*}\uparrow^{*}$ $\mathbf{-7.81}^{***}$	Jun 2005 $\downarrow^{*}$ Oct 2006 $\downarrow^{*}$ -5.18	**Apr 2004** $\uparrow \downarrow^{*}$ **Jul 2003** $\downarrow^{*}$ $\mathbf{-8.20}^{***}$
Credsharecards	Aug 2003 $\uparrow \downarrow^{*}$ Aug 2005 $\downarrow^{*}\uparrow^{*}$ -6.51^{*}	Jan 2003 $\uparrow^{*}$ Mar 2005 $\downarrow^{*}$ -4.24	May 2003 $\uparrow^{*}\downarrow^{*}$ Sep 2006 $\uparrow^{*}$ -5.20
Credsharecreddeb	Nov 2004 $\uparrow \downarrow^{*}$ Feb 2006 $\uparrow^{*}\uparrow^{*}$ -6.62^{*}	May 2003 $\uparrow^{*}$ May 2005 $\downarrow^{*}$ -5.54	May 2003 $\uparrow^{*}\downarrow$ May 2005 $\downarrow^{*}$ -5.48
May 1994-Jun 2007	**Jan 1997** $\downarrow^{*}\uparrow^{*}$ **Dec 2001** $\downarrow^{*}\downarrow^{*}$ $\mathbf{-8.72}^{***}$	**Dec 1998** $\uparrow^{*}$ **Dec 2001** $\downarrow^{*}$ $\mathbf{-6.67}^{**}$	**Dec 2001** $\downarrow^{*}\downarrow^{*}$ **Feb 1999** $\uparrow^{*}$ $\mathbf{-7.63}^{***}$
Credsharecredchar	Mar 2003 $\uparrow^{*}\downarrow^{*}$ Jul 2005 $\uparrow^{*}\uparrow^{*}$ -6.19	Jan 2003 $\uparrow^{*}$ Mar 2004 $\downarrow^{*}$ -5.24	Mar 2005 $\downarrow \uparrow^{*}$ Jan 2003 $\uparrow^{*}$ -5.98

***, **, * indicate significant at 1%, 5% and 10% level respectively. Series in bold reject the unit root null at the 5% level in favour of a break in the series. Critical values from (Ben-David et al., 2003), updated from the original values (Lumsdaine & Papell, 1997). Model CC critical values are -7.19, -6.75 and -6.48 at the 1, 5 and 10% significance levels respectively. Similarly Model AA critical values are -6.74, -6.16 and -5.89 and Model CA critical values are -7.19, -6.62 and -6.37.

Arrows indicate the direction of the break. * on the arrow indicates that the coefficient was significant at the 5% level. This is not reliable where the unit root null is not rejected.

a All series are deseasonalised with dummy variables except for both Log credaccts series.

Table 8 Break point tests for Δ Log credaccts

Coefficient (p value)	**Δ Log credaccts**	**Δ Log credaccts**
Newy West lags[a]	NA	NA
Intercept dummy (D_L)	0.0089 (0.002)	0.0102 (0.000)
Lag (Y_{t-1})	0.0814 (0.608)	
Lag interaction ($D_L * Y_{t-1}$)	0.2361 (0.324)	
Time (T)	0.000358 (0.005)	0.000278 (0.016)
Time interaction (D_T)	-0.000404 (0.002)	-0.000345 (0.005)
ΔInterest	0.0353 (0.001)	0.0309 (0.003)
ΔInterest interaction (ΔInterest * D_T)	-0.0309 (0.008)	-0.0246 (0.032)
Joint seasonal dummies significant?	✗	✗
F test of break slope dummies	4.83 (0.005)	5.27 (0.009)
F test of break dummies	5.65 (0.001)	8.61 (0.000)
R^2	0.6258	0.5776
Adjusted R^2	0.4761	0.4368
N	64	65

a OLS regression with 12 lag Newey West (1987) standard errors was not used as testing using the Stata bgodfrey module failed to reject the null of no serial correlation with 12 lags at the 5% significance level.

9. Summary & Discussion

A major set of reforms to the Australian credit card including a near halving of the interchange fee and the lifting of restrictions on merchant's surcharging occurred in Australia at the end of October 2003. These reforms were widely expected to have a negative effect on the relative attractiveness of credit card use. However a battery of econometric tests has failed to find evidence of a negative effect on credit card transaction levels and market shares at the time of the reforms. This includes tests for an immediate impact in the shape of intercept shifts and more gradual shifts in the form of changes to the trend function.

Initial unit root tests with and without an exogenous break point assumption failed to reject the null of a unit root for the majority of the series. Chow type tests for a structural break with an exogenous break date were done on the series which rejected the null of a unit root – the growth in credit card transaction value (Δ Log credval), for January 2002 to June 2007. No significant negative break was found in these tests.

Unit root tests allowing for one endogenously determined structural break in the intercept, the trend or both were done. Further tests allowing for two endogenously determined structural breaks were also done. Where a unit root was rejected the endogenously determined break points tended to coincide with interest rate changes. In the extended series break points also coincided with RBA data collection changes and the introduction of the Goods and Services Tax.

No series rejected the null of a unit root and had a negative indicative break date at the time of the reforms. This is despite the fact that the introduction of the reforms was immediately followed by successive interest rate increases in November 2003 and December 2003. The combination of credit card reforms and successive interest rate rises was not sufficient for the time of the reforms to register as an endogenously determined negative break date.

The time of the credit card reforms did coincide with an increase in the intercept of the credit card account growth rate series. The credit card issuers changed key features of credit cards around this time including introducing and increasing annual card fees and reducing rewards for credit card use. These changed offerings appear to have induced many cardholders to open new accounts, as they have sought cards more to their taste. They may not have closed their old accounts and indeed may be increasingly using different accounts for different purposes. In any event the net effect was a net positive increase in the intercept of the credit card account growth rate.

Interest rate changes were found to coincide with several of the endogenously determined break dates. Interest rate increases were associated with negative structural breaks and interest rate decreases were associated with positive structural breaks. The Chow type tests were conditioned on interest rate changes. As expected, these also indicated that interest rate rises were associated with declining credit card transaction growth and vice versa.

For credit card accounts interest rate rises were associated with increases in the growth rate of credit card accounts. We surmise that some people use a new account as a means to deal with short term credit constraints and that this phenomenon is more common at the time of interest rate rises. This phenomenon also appears to have reduced with the advent of the reforms. We attribute this to the increased fixed cost of credit card accounts in the form of annual fees. The fees make it more expensive to buy another credit card to use for short term cash flow issues brought on by interest rate rises.

Testing the credit card market share of the total cards market and of the narrower credit and debit card market and credit and charge card markets consistently failed to reject the null hypothesis of a unit root. In effect in a unit root process permanent shocks occur frequently whereas in a trend process with a structural break or two, such shocks occur relatively rarely. These markets would appear to have been subject to frequent permanent shocks over the time period January 2002 to June 2007.

The econometric evidence indicates that the significant credit card reforms, coupled with two interest rate rises, were not associated with negative breaks in key credit card transaction growth rates and market shares. This in turn implies that the Australian credit card market did not behave as a two sided market as defined by Rochet and Tirole (2006). Instead the credit card market response appears neutral in the sense of Gans and King (2003a), where a significant price change has not lead to significant changes in real transaction levels.

The theory of two sided markets remains valuable for credit card markets, particularly in their nascent stages. However once a credit card market is well established it may behave less like the two sided market of Rochet and Tirole (2006) where the distribution of prices between cardholders and merchants is critical to transaction levels. An established credit card market such as Australia's in the 21st century, with a high market share and a preponderance of merchant acceptance, has proved to be very resilient to a major price distribution shock and associated reforms.

If these reforms had occurred earlier in the development of the credit card market then a different story may have unfolded. It is plausible that credit card markets that are yet to establish such a firm foothold would be much more affected by these reforms than a mature market with widespread card use and acceptance.

This paper makes no direct comment on the desirability of the reforms for the purposes of redistributing the costs of credit card use. It may well be that the reforms have had the effect that users of credit cards are bearing the costs of using credit cards more directly via annual fees and merchant surcharges. However this is yet to show up in a distinct break in credit card transaction levels, growth rates or market shares. People appear to have adjusted to the reforms without a structural break in their behaviour in choosing between the major payment instruments.

This analysis suggests there is a reduced case for continued emphasis on the regulation of the interchange fee, given the unresponsiveness of the market to the near halving of the fee. The reforms and continued regulation of the interchange fee impose direct regulatory oversight costs such as monitoring and ensuring compliance. There is also the potential for significant indirect costs in the form of uncertainty on players throughout the payment system.

10.Conclusion

We could find no evidence that the major credit card reforms in Australia in October 2003, including a near halving of the interchange fee from 0.95% to 0.55%, led to a significant negative shift in credit card usage, growth rates or market shares. Instead the impact on credit card fees and merchant service charges but not on payment instrument choice and usage is consistent with the neutrality hypothesis. We did find evidence of a positive structural break in the growth rate of credit card accounts associated with the time of the reforms. The reforms appear to have led credit card issuers to restructure their card offerings and this has prompted people to seek new accounts, while not necessarily completely abandoning their old accounts.

Appendix A Program code for Zivot Andrews tests

The following is a sample Stata ado file used to perform the Zivot and Andrews tests. The sample code is for the test with a break in both the intercept and the trend, Model C.

```
*! zandrews1
* By R Hayes
* Sections of code borrowed and inspired from clemio2 and zandrews by C F Baum
program define zandrews1, rclass byable(recall)
	version 8.2
	syntax varname(ts) [if] [in] [ , Maxlag(integer 12) graph]
	marksample touse
				/* get time variables; permit onepanel */
*	_ts timevar, sort
   _ts timevar panelvar if `touse', sort onepanel
	markout `touse' `timevar'
	tsreport if `touse', report
	if r(N_gaps) {
		di in red "sample may not contain gaps"
		exit
	}
	qui tsset
	local rts = r(tsfmt)
	tempvar count samp sampn dvar du1 dt1 mint t
	if `maxlag' < 1 {
		di in r _n "Error: maxlag must be positive."
		exit 198
		}
	local kmax `maxlag'
	g `t' = _n
	qui gen `count' = sum(`touse')
	qui gen `samp' = `touse'
	local nobs = `count'[_N]
	display `nobs'
	local ntrim=1
	local ntrimstart=max(`ntrim', `kmax'+1)
	qui replace `samp' = 0  if `count' <= `ntrimstart'
	qui gen `dvar' = D.`varlist' if `touse'
	local tmin 10^99

	scalar _cv = 1.6
	qui {
		gen `du1' = .
		gen `dt1' = .
		gen `sampn' = _n if `samp'==1
*		sum `sampn', meanonly
* onepanel per zandrews
		sum `count' if `samp', meanonly
		if "`graph'" ~= "" gen `mint' = .
	}
	local first = r(min)+1
	local last = r(max)-1
	local newnobs = `last' - `first' + 1
	forv i = `first'/`last' {
		qui  {
*			replace `du1' = (_n > `i')
*			replace `dt1' = (_n == `i' + 1)
```

```
* onepanel

                replace `du1' = (`count' > `i')
                        replace `dt1' = 0
                        replace `dt1' = `count' - `i' if `count'-`i'>0

        local rhs "L.`varlist' `count' `dt1' `du1'"

        forv j = `kmax'(-1)1 {

                 qui {
                        regress `varlist' `rhs' L(1/`j').`dvar' if `touse'
                        }
                local find`j' = _b[L.`j'.`dvar'] / _se[L.`j'.`dvar']
                }

        local kopt 0
        forv j = `kmax'(-1)1 {
                if `find`j'' > _cv | `find`j'' < -_cv {
                        local kopt `j'

                        continue, break
                        }
        }

        if `kopt' == 0 {
                qui regress `varlist' `rhs' if `touse'

                }
        else {
                qui regress `varlist' `rhs' L(1/`kopt').`dvar' if `touse'
                }

                        }

                        local tdu = (_b[L.`varlist']-1.0) / _se[L.`varlist']

*                       if "`graph'" ~= "" qui replace `mint' = `tdu' in `i'/`i'
                        if "`graph'" ~= "" qui replace `mint' = `tdu' if `count'==`i'

                        if `tdu' < `tmin' {
                                local tmin = `tdu'
                                local bobsmin1 = `i'
                                local koptopt = `kopt'
                                su `t' if `count'==`i', meanonly
                                local minobs = r(mean)
                                        }

* display `i'
* display `kopt'
* display `tdu'
* display `tmin'
                }

        local topt = `tmin'
        local Tb1 = `bobsmin1'
        local kopt1 = `koptopt'

                        replace `du1' = (`count' > `Tb1')
                        replace `dt1' = 0
```

```
                    replace `dt1' = `count' - `Tb1' if `count'-`Tb1'>0
        local rhs "L.`varlist' `count' `dt1' `du1'"
        if `kopt1' == 0 {
                qui regress `varlist' `rhs' if `touse'

                }
        else {
                qui regress `varlist' `rhs' L(1/`kopt1').`dvar' if `touse'
                }

        local en e(df_r)
        return scalar effN = `newnobs'
        return scalar kopt = `kopt1'
*       return scalar Tb1 = `timevar'[`Tb1']
        return scalar Tb1 = `timevar'[`minobs']
        return scalar coef1 = _b[`du1']
        return scalar tstv1 = _b[`du1'] / _se[`du1']
        return scalar coef2 = _b[`dt1']
        return scalar tstv2 = _b[`dt1'] / _se[`dt1']
        return scalar coef3 = _b[_cons]
        return scalar tstv3 = _b[_cons] / _se[_cons]
        return scalar coef4 = _b[`count']
        return scalar tstv4 = _b[`count'] / _se[`count']
        return scalar rho   = _b[L.`varlist'] - 1.0
        return scalar tst   = return(rho) / _se[L.`varlist']
        local pu1 = 2*ttail(`en',abs(return(tstv1)))
        local pu2 = 2*ttail(`en',abs(return(tstv2)))
        local pu3 = 2*ttail(`en',abs(return(tstv3)))
        local pu4 = 2*ttail(`en',abs(return(tstv4)))
        local ne = char(241)+char(233)
        if "$S_OS" == "MacOSX" {
                local ne = char(150)+char(142)
                }
        di in gr _n "Zivot Andrews test with break in trend and intercept, k varying by breakpoint"
        di in ye _n "`varlist'" in gr "    T =" %5.0f return(effN)  _col(25) " optimal breakpoint : " in ye
`rts' return(Tb1)
        di in gr _n  "AR(" in ye %2.0f return(kopt) in gr ")" _col(18) "du1" _col(31) "dt1" _col(41)
"(rho - 1)" _col(56) "const" _col(66) "time"
        di as text "{hline 73}"
        di in gr "Coefficients: " in ye _col(12) %12.5f return(coef1) _col(25) %12.5f return(coef2)
_col(35) %12.5f return(rho)  /*
        */  _col(50) %10.5f return(coef3) _col(60) %10.5f return(coef4)
        di in gr "t-statistics: " in ye _col(12) %12.5f return(tstv1)  _col(25) %12.5f return(tstv2)
_col(35) %12.5f return(tst) _col(50) %10.5f return(tstv3) _col(60) %10.5f return(tstv4)
        di in gr "P-values:" _col(15) %12.5f `pu1' _col(27) %12.5f `pu2' _col(43) " -5.08cv" _col(48)
%10.5f `pu3' _col(58) %10.5f `pu4'

/* Critical values from Zivot Andrews: Further Evidence on the Great Crash, the Oil-Price Shock, and
the Unit-Root Hypothesis
Eric Zivot; Donald W. K. Andrews
Journal of Business & Economic Statistics, Vol. 10, No. 3. (Jul., 1992), pp. 251-270.
*/

* graph option
if "`graph'" ~= "" {
        label var `dvar' "D.`varlist'"
        label var `mint' "breakpoint t-statistic"
        local minx = return(Tb1)
        local minp = string(return(Tb1),"`rts'")
```

```
	tsline `mint' if `mint'<., ti("Breakpoint t-statistic: min at `minp'") xline(`minx') nodraw name(mint,replace)
	tsline `dvar' if `mint'<., ti("D.`varlist'") nodraw xline(`minx') name(ddv,replace)
	graph combine ddv mint, col(1) ti("Zivot Andrews test with break in trend and intercept") ///
		subti("in series: `varlist'")
}

	end
	exit
```

Appendix B Program code for Lumsdaine Papell tests

The following is a sample Stata ado file used to perform the Lumsdaine and Papell tests. The sample code is for Model CC, with two breaks in the intercept and trend.

```
*! lumsdaine1 version 1.1 Aug 2007   R Hayes
* Sections of code borrowed and inspired from clemio1, clemio2 and zandrews routines by C F Baum
program define lumsdaine1, rclass byable(recall)
	version 8.2
	syntax varname(ts) [if] [in] [ , Maxlag(integer 12)  graph]
	marksample touse
				/* get time variables; permit onepanel */
*	_ts timevar, sort
   _ts timevar panelvar if `touse', sort onepanel
	markout `touse' `timevar'
	tsreport if `touse', report
	if r(N_gaps) {
		di in red "sample may not contain gaps"
		exit
	}
	qui tsset
	local rts = r(tsfmt)
	tempvar count samp sampn dvar du1 dt1 du2 dt2 mint t
	if `maxlag' < 1 {
		di in r _n "Error: maxlag must be positive."
		exit 198
		}
	local kmax `maxlag'
	g `t' = _n
	qui	gen `count' = sum(`touse')
	qui gen `samp' = `touse'
	local nobs = `count'[_N]
	local ntrim=1
	local ntrimstart=max(`ntrim', `kmax'+1)
	qui replace `samp' = 0  if `count' <= `ntrimstart'
	qui gen `dvar' = D.`varlist' if `touse'
	local tmin 10^99
* pick up level from system setting
	scalar _cv = 1.6
	qui{
		gen `du1' = .
		gen `dt1' = .
		gen `du2' = .
		gen `dt2' = .
		gen `sampn' = _n if `samp'==1
*		sum `sampn', meanonly
* onepanel per zandrews
		sum `count' if `samp', meanonly
```

```
				if "`graph'" ~= "" gen `mint' = .
				}
			local first = r(min)+1
			local last = r(max)-1
			local last2 = `last'-2
			local newnobs = `last' - `first' + 1
			forv i = `first'/`last2' {
				qui {
*						replace `du1' = (_n > `i')
*						replace `dt1' = (_n == `i' + 1)
* onepanel
						replace `du1' = (`count' > `i')
						replace `dt1' = 0
						replace `dt1' = `count' - `i' if `count'-`i'>0
						}
						local ip2 = `i' + 2
						forv jj = `ip2'/`last' {
				qui {
*								replace `du2' = (_n > `j')
*								replace `dt2' = (_n == `j' + 1)
* onepanel
								replace `du2' = (`count' > `jj')
								replace `dt2' = 0
								replace `dt2' = `count' - `jj' if `count' - `jj' > 0
						}
			local rhs "L.`varlist' `count' `dt1' `du1' `dt2' `du2'"



			forv j = `kmax'(-1)1 {

				 qui {
						regress `varlist' `rhs' L(1/`j').`dvar' if `touse'
						}
				local find`j' = _b[L.`j'.`dvar'] / _se[L.`j'.`dvar']
				}

			local kopt 0
			forv j = `kmax'(-1)1 {
				if `find`j'' > _cv | `find`j'' < -_cv {
						local kopt `j'

						continue, break
						}
			}


			if `kopt' == 0 {
				qui regress `varlist' `rhs' if `touse'

				}
			else {
				qui regress `varlist' `rhs' L(1/`kopt').`dvar' if `touse'
				}

* display `kopt'

						local tdu = (_b[L.`varlist']-1.0) / _se[L.`varlist']
*						if "`graph'" ~= "" qui replace `mint' = `tdu' in `i'/`i'
						if "`graph'" ~= "" qui replace `mint' = `tdu' if `count'==`i'
```

```
                    if `tdu' < `tmin' {
                              local tmin = `tdu'
                              local bobsmin1 = `i'
                              local bobsmin2 = `jj'
                              local koptopt = `kopt'
                              su `t' if `count'==`i', meanonly
                              local minobs1 = r(mean)
                              su `t' if `count'==`jj', meanonly
                              local minobs2 = r(mean)
                                        }
                              }
          }

local topt = `tmin'
local Tb1 = `bobsmin1'
local Tb2 = `bobsmin2'
local kopt1 = `koptopt'

                    replace `du1' = (`count' > `Tb1')
                    replace `dt1' = 0
                    replace `dt1' = `count' - `Tb1' if `count'-`Tb1'>0
                    replace `du2' = (`count' > `Tb2')
                    replace `dt2' = 0
                    replace `dt2' = `count' - `Tb2' if `count'-`Tb2'>0
local rhs "L.`varlist' `count' `dt1' `du1' `dt2' `du2'"
if `kopt1' == 0 {
          qui regress `varlist' `rhs' if `touse'
          }
else {
          qui regress `varlist' `rhs' L(1/`kopt1').`dvar' if `touse'
          }

local en e(df_r)
return scalar effN = `newnobs'
return scalar kopt = `kopt1'
*         return scalar Tb1 = `timevar'[`Tb1']
return scalar Tb1 = `timevar'[`minobs1']
return scalar Tb2 = `timevar'[`minobs2']
return scalar coef1 = _b[`du1']
return scalar tstv1 = _b[`du1'] / _se[`du1']
return scalar coef2 = _b[`dt1']
return scalar tstv2 = _b[`dt1'] / _se[`dt1']

return scalar coef3 = _b[_cons]
return scalar tstv3 = _b[_cons] / _se[_cons]
return scalar coef4 = _b[`count']
return scalar tstv4 = _b[`count'] / _se[`count']
return scalar coef5 = _b[`du2']
return scalar tstv5 = _b[`du2'] / _se[`du2']
return scalar coef6 = _b[`dt2']
return scalar tstv6 = _b[`dt2'] / _se[`dt2']
return scalar rho   = _b[L.`varlist'] - 1.0
return scalar tst   = return(rho) / _se[L.`varlist']
local pu1 = 2*ttail(`en',abs(return(tstv1)))
local pu2 = 2*ttail(`en',abs(return(tstv2)))
local pu3 = 2*ttail(`en',abs(return(tstv3)))
local pu4 = 2*ttail(`en',abs(return(tstv4)))
local pu5 = 2*ttail(`en',abs(return(tstv5)))
local pu6 = 2*ttail(`en',abs(return(tstv6)))
local ne = char(241)+char(233)
```

```
	if "$S_OS" == "MacOSX" {
		local ne = char(150)+char(142)
		}

	di in gr _n "Lumsdaine Papell test with 2 breaks in trend and intercept, k varies by breakpoint"
	di in ye _n "`varlist'" in gr "    T =" %5.0f return(effN)  _col(25) " optimal breakpoints : " in ye `rts' return(Tb1) " , " `rts' return(Tb2)
	di in gr _n  "AR(" in ye %2.0f return(kopt) in gr ")" _col(18) "du1" _col(25) "dt1" _col(33) "(rho - 1)" _col(43) "const" _col(52) "time" _col(62) "du2" _col(72) "dt2"
	di as text "{hline 73}"
	di in gr "Coefficients: " in ye _col(9) %8.5f return(coef1) _col(24) %8.5f return(coef2) _col(33) %8.5f return(rho)  /*
	*/  _col(42) %8.5f return(coef3) _col(51) %8.5f return(coef4) _col(61) %8.5f return(coef5) _col(71) %8.5f return(coef6)
	di in gr "t-statistics: " in ye _col(9) %8.5f return(tstv1)  _col(24) %8.5f return(tstv2) _col(33) %8.5f return(tst) _col(42) %8.5f return(tstv3) _col(51) %8.5f return(tstv4) _col(61) %8.5f return(tstv5) _col(71) %8.5f return(tstv6)
	di in gr "P-values:" _col(15) %8.5f `pu1' _col(24) %8.5f `pu2' _col(30) " -6.75cv" _col(42) %8.5f `pu3' _col(51) %8.5f `pu4' _col(61) %8.5f `pu5' _col(71) %8.5f `pu6'
/* Critcial values from Ben-David, Lumsdaine and Papell
Unit roots, postwar slowdowns and long-run growth: Evidence from two structural breaks
Dan Ben-David, Robin L. Lumsdaine, David H. Papell
Empirical Economics (2003) 28:303–319
*/

	* graph option
if "`graph'" ~= "" {
	label var `dvar' "D.`varlist'"
	label var `mint' "breakpoint t-statistic"
	local minx1 = return(Tb1)
	local minx2 = return(Tb2)
	local minp1 = string(return(Tb1),"`rts'")
	local minp2 = string(return(Tb2),"`rts'")
	tsline `varlist' if `samp', ti("Test on `varlist': breaks at `minp1',`minp2'") xline(`minx1' `minx2') nodraw name(ser,replace)
	tsline `dvar' if `samp', ti("D.`varlist'") nodraw xline(`minx1' `minx2') name(ddv,replace)
	graph combine ser ddv, col(1) ti("Lumsdaine Papell 2 break test for unit root")
}

end
exit
```

References

Abubader, S. (2002). Institutional changes and breakpoints in Israeli trade [Electronic version]. *Applied Economics, 34*(15), 1893-1901.

Akaike, H. (1974). A new look at the statistical model identification [Electronic version]. *IEEE Transactions on Automatic Control, AC19*(6), 716-723.

Australian Bureau of Statistics. (2007a). Australian national accounts: National income, expenditure and product, Mar 2007. *Table 8. Household final consumption expenditure (HFCE): Chain volume measures; Original, time series spreadsheet, Cat. no. 5206.0, Series ID A2302431X* Retrieved 16 August 2007, from http://www.ausstats.abs.gov.au/ausstats/abs@archive.nsf/0/EFCA89FE25337FDCCA2572F10017D849/$File/5206008_household_final_consumption_expenditure.xls

Australian Bureau of Statistics. (2007b). Consumer price index, Australia. *Tables 1 and 2. CPI: All groups, index numbers and percentage changes, time series spreadsheet, Cat. no. 6401.0, Series ID A2325846C* Retrieved 16 August 2007, from http://www.ausstats.abs.gov.au/ausstats/abs@archive.nsf/0/29958FB4F0D7761DCA25732200217359/$File/640101.xls

Baxter, W. F. (1983). Bank interchange of transactional paper: Legal and economic perspectives [Electronic version]. *Journal of Law and Economics, 26*(3), 541-588.

Ben-David, D., Lumsdaine, R. L., & Papell, D. H. (2003). Unit roots, postwar slowdowns and long-run growth: Evidence from two structural breaks [Electronic version]. *Empirical Economics, 28*(2), 303-319.

Breusch, T. S. (1978). Testing for autocorrelation in dynamic linear models [Electronic version]. *Australian Economic Papers, 17*(31), 334-355.

Carlton, D. W., & Frankel, A. S. (1995). The antitrust economics of credit card networks [Electronic version]. *Antitrust Law Journal, 63*, 643-668.

Chang, H., Evans, D. S., & Garcia Swartz, D. D. (2005). The effect of regulatory intervention in two-sided markets: An assessment of interchange-fee capping in Australia [Electronic version]. *Review of Network Economics, 4*(4), 328-358.

Chow, G. C. (1960). Tests of equality between sets of coefficients in two linear regressions [Electronic version]. *Econometrica, 28*(3), 591-605.

Clemente, J., Montañés, A., & Reyes, M. (1998). Testing for a unit root in variables with a double change in the mean [Electronic version]. *Economics Letters, 59*(2), 175-182.

Cruickshank, D. (2000). *Competition in UK banking: A report to the Chancellor of the Exchequer*. London: The Stationery Office.

Dickey, D. A., Bell, W. R., & Miller, R. B. (1986). Unit roots in time series models: Tests and implications [Electronic version]. *American Statistician, 40*(1), 12-26.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root [Electronic version]. *Journal of the American Statistical Association, 74*(366), 427-431.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root [Electronic version]. *Econometrica, 49*(4), 1057-1072.

Dickey, D. A., Hasza, D. P., & Fuller, W. A. (1984). Testing for unit roots in seasonal time series [Electronic version]. *Journal of the American Statistical Association, 79*(386), 355-367.

Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient tests for an autoregressive unit root [Electronic version]. *Econometrica, 64*(4), 813-836.

Enders, W. (2004). *Applied econometric time series* (2nd ed.). Hoboken, NJ: J. Wiley.

European Commission. (2000). Commission plans to clear certain VISA provisions, challenge others. [Press release 16 October 2003] IP/00/1164. Retrieved 12 March 2007, from http://www.europa.eu/rapid/pressReleasesAction.do?reference=IP/00/1164&format=HTML&aged=1&language=EN&guiLanguage=en

Evans, D. S. (2003). The antitrust economics of multi-sided platform markets [Electronic version]. *Yale Journal on Regulation, 20*, 325-382.

Evans, D. S., & Schmalensee, R. (2005). *Paying with plastic: The digital revolution in buying and borrowing* (2nd ed.). Cambridge, MA and London, UK: MIT Press.

Financial System Inquiry. (1997). *Final report*. Canberra, Australia: Australian Government Publishing Service.

Frankel, A. S. (1998). Monopoly and competition in the supply and exchange of money [Electronic version]. *Antitrust Law Journal, 66*, 313-361.

Fuller, W. A. (1976). *Introduction to statistical time series*. New York: Wiley.

Gans, J. S., & King, S. P. (2003a). The neutrality of interchange fees in payment systems [Electronic version]. *Topics in Economic Analysis and Policy, 3*(1).

Gans, J. S., & King, S. P. (2003b). A theoretical analysis of credit card reform in Australia [Electronic version]. *Economic Record, 79*(247), 462-472.

Ghysels, E., & Perron, P. (1993). The effect of seasonal adjustment filters on tests for a unit root [Electronic version]. *Journal of Econometrics, 55*(1-2), 57-98.

Ghysels, E., & Perron, P. (1996). The effect of linear filters on dynamic time series with structural change [Electronic version]. *Journal of Econometrics, 70*(1), 69-97.

Godfrey, L. G. (1978). Testing for higher order serial correlation in the regression equations when regressors include lagged dependent variables [Electronic version]. *Econometrica, 46*(6), 1303-1310.

Hall, A. (1994). Testing for a unit root in time series with pretest data-based model selection [Electronic version]. *Journal of Business & Economic Statistics, 12*(4), 461-470.

Harris, R. I. D. (1992). Testing for unit roots using the augmented Dickey-Fuller test: Some issues relating to the size, power and the lag structure of the test. *Economics Letters, 38*(4), 381-386.

Hylleberg, S., Engle, R. F., Granger, C. W. J., & Yoo, B. S. (1990). Seasonal integration and cointegration [Electronic version]. *Journal of Econometrics, 44*(1-2), 215-238.

Lumsdaine, R. L., & Papell, D. H. (1997). Multiple trend breaks and the unit-root hypothesis [Electronic version]. *Review of Economics and Statistics, 79*(2), 212-218.

Maddala, G. S., & Kim, I.-M. (1998). *Unit roots, cointegration, and structural change*. Cambridge [England] ; New York: Cambridge University Press.

Miron, J. A. (1996). *The economics of seasonal cycles*. Cambridge, MA: MIT Press.

Newey, W. K., & West, K. D. (1987). A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix [Electronic version]. *Econometrica, 55*(3), 703-708.

Ng, S., & Perron, P. (1995). Unit root tests in ARMA models with data-dependent methods for the selection of the truncation lag [Electronic version]. *Journal of the American Statistical Association, 90*(429), 268-281.

Ng, S., & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power [Electronic version]. *Econometrica, 69*(6), 1519-1554.

Perron, P. (1989). The Great Crash, the oil price shock, and the unit root hypothesis [Electronic version]. *Econometrica, 57*(6), 1361-1401.

Perron, P., & Vogelsang, T. J. (1992). Nonstationarity and level shifts with an application to purchasing power parity [Electronic version]. *Journal of Business & Economic Statistics, 10*(3), 301-320.

Reserve Bank of Australia. (2001). *Reform of credit card schemes in Australia I: A consultation document*. Sydney, Australia: Reserve Bank of Australia.

Reserve Bank of Australia. (2003). The changing Australian retail payments landscape, *Reserve Bank of Australia Bulletin*. Sydney, Australia: Reserve Bank of Australia.

Reserve Bank of Australia. (2004). *Payments System Board: 2004 Annual report*. Sydney, Australia: Reserve Bank of Australia.

Reserve Bank of Australia. (2005). *Payments System Board: 2005 Annual report*. Sydney, Australia: Reserve Bank of Australia.

Reserve Bank of Australia. (2006). *Payments System Board: 2006 Annual report*. Sydney, Australia: Reserve Bank of Australia.

Reserve Bank of Australia. (2007a). Additional credit card statistics. Retrieved 16 August 2007, from http://www.rba.gov.au/PaymentsSystem/PaymentsStatistics/ExcelFiles/RPS.xls

Reserve Bank of Australia. (2007b). Bulletin table C1 - Credit and charge card statistics. Retrieved 16 August 2007, from http://www.rba.gov.au/Statistics/Bulletin/C01hist.xls

Reserve Bank of Australia. (2007c). Bulletin table C4 - Debit card statistics. Retrieved 16 August 2007, from http://www.rba.gov.au/Statistics/Bulletin/C04hist.xls

Reserve Bank of Australia. (2007d). Bulletin table C5 - Cheques and direct entry payments. Retrieved 16 August 2007, from http://www.rba.gov.au/Statistics/Bulletin/C05hist.xls

Reserve Bank of Australia and Australian Competition and Consumer Commission. (2000). *Debit and credit card schemes in Australia: A study of interchange fees and access*. Sydney, Australia: Reserve Bank of Australia.

Rochet, J.-C., & Tirole, J. (2002). Cooperation among competitors: Some economics of payment card associations [Electronic version]. *RAND Journal of Economics, 33*(4), 549-570.

Rochet, J.-C., & Tirole, J. (2003). Platform competition in two-sided markets [Electronic version]. *Journal of the European Economic Association, 1*(4), 990-1029.

Rochet, J.-C., & Tirole, J. (2006). Two-sided markets: A progress report [Electronic version]. *RAND Journal of Economics, 37*(3), 645-667.

Saikkonen, P., & Lütkepohl, H. (2000). Testing for the cointegrating rank of a VAR process with structural shifts [Electronic version]. *Journal of Business & Economic Statistics, 18*(4), 451-464.

Schmalensee, R. (2002). Payment systems and interchange fees [Electronic version]. *Journal of Industrial Economics, 50*(2), 103-122.

Schwarz, G. (1978). Estimating the dimension of a model [Electronic version]. *Annals of Statistics, 6*(2), 461-464.

Schwert, G. W. (1989). Tests for unit roots: A Monte Carlo investigation [Electronic version]. *Journal of Business & Economic Statistics, 7*(2), 147-159.

Virgin Money. (2003). Australian credit card market set for major shape up as Virgin launches 'best ever' [Media release 12 May 2003]. http://virginmoney.com.au/export/sites/virginmoney/downloads/National_Launch_Release_-_FINAL.doc Retrieved 12 March 2007

Wooldridge, J. M. (2003). *Introductory econometrics: A modern approach* (2nd ed.). Australia ; Cincinnati, Ohio: South-Western College Pub.

Wright, J. (2003). Optimal card payment systems [Electronic version]. *European Economic Review, 47*(4), 587-612.

Zivot, E., & Andrews, D. W. K. (1992). Further evidence on the Great Crash, the oil-price shock, and the unit-root hypothesis [Electronic version]. *Journal of Business & Economic Statistics, 10*(3), 251-270.