Is price regulation of payment card associations effective? Evidence from a dramatic policy experiment

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This Version: 21st January, 2010

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 the growth rate of credit card account numbers.

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1. Introduction

Credit card fee practices are under scrutiny around the world. The US alone has seen a flurry of activity. Visa and MasterCard paid around $3B in 2003 and agreed to end the "honor all cards" rule to settle the "Wal-Mart case", where tying of credit and debit cards was claimed to be a device to impose anticompetitive interchange fees.[1] In 1998 the Department of Justice sued Visa and MasterCard for alleged antitrust violations with mixed results, including the finding that Visa and MasterCard had market power in the network services market.[2] The Department of Justice continues to investigate the prevailing rules preventing merchants from surcharging credit card use, discriminating against cards by type or suggesting alternative payment methods for card transactions (U.S. Government Accountability Office, 2009). The latest private litigation, a consolidation of at least 14 separate lawsuits against Visa and MasterCard is headed to a New York District Court, with merchants claiming that interchange fees have an anticompetitive effect that violates the federal antitrust laws.[3] US lawmakers jostle to legislate against certain credit card fee practices.[4]

The two-sided nature of payment card markets complicates the competition assessment of their rules and fees. Payment card platforms feature powerful adoption externalities, where users benefit from widespread merchant acceptance and merchants prefer a payment platform with more cards in use than one with fewer cards. Pricing structures and rules develop to ensure that both card users and merchants have incentives to hold and accept the card. Prices need not reflect costs and may even be negative to encourage one side of the market, such as card customers receiving reward points.

A key price in this balancing act, the interchange fee, is paid by merchant acquirers to card issuers. An increase in the interchange fee leads the merchant acquirer bank to raise charges to the merchant, while raising incentives for issuer banks to encourage credit card use such as by lowering card holder fees. So changing the interchange fee allows the card associations to change the balance of costs they recover between customers and merchants (Baxter, 1983).

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[1] In re Visa Check/Mastermoney Antitrust Litig., 396 F.3d 96 (2d Cir. 2005), aff'g 297 F. Supp. 2d 503 (E.D.N.Y., 2003).

[2] United States v. Visa U.S.A., Inc., 344 F.3d 229 (2d Cir. 2003), aff'g, 163 F . Supp. 2d. 322 (S.D.N.Y. 2001) and cert. denied, 543 U.S. 811 (2004).

[3] In re Payment Card Interchange Fee and Merchant Discount Antitrust Litigation, 2006 U.S.Dist. LEXIS 45727; 2006-1 Trade Cas. (CCH) P75,278 (E.D.N.Y.).

[4] For example the Credit Card Fair Fee Acts of 2009, would allow an exemption from federal antitrust laws for merchant groups to collectively negotiate interchange fees, those interchange fees would be made publicly available. The proposed Credit Card Interchange Fees Act of 2009 would remove requirements for merchants to accept all cards from a given network, and also require interchange fee disclosure.

Rochet and Tirole (2003, 2006) suggest that the very definition of a two-sided market is a market with network externalities where platforms can cross subsidise different categories of end users in the transaction. So in two-sided markets transaction levels are affected by how prices, such as the interchange fee, are distributed between merchants and cardholders, in turn affecting relative usage rates. For example the simple addition of a no surcharge rule has been shown to allow the use of interchange fees to extract rents from consumers who do not even use a credit card (Rochet & Tirole, 2002). The mechanism is higher interchange fees leading to higher merchant service fees, and in the absence of surcharging, these are recovered by merchants from all consumers. Though this may decrease merchant preference for the adoption of credit cards, adoption network effects may be enough to overcome this, leading to over-use of cards as a payment instrument from a social perspective.

A critical area of theoretical development in credit card markets has been analyses of when interchange fees are expected to be neutral versus when interchange fees are expected to have real economic effects. Neutrality here means that changes to the interchange fee give rise to changes to prices such as merchant service fees, prices and cardholder fees but do not affect consumer decisions about card use and merchant decisions about accepting cards. Gans and King (2003a) provide a theoretical result that whenever "payment separation" occurs the interchange fee is neutral. Payment separation effectively means that there is a different price available for cash paying customers and credit card paying customers.

The Reserve Bank of Australia (RBA) investigated credit card fee practices and due to concerns over credit card over-use it implemented a package of reforms. After the removal of no surcharging rules, credit card interchange fees were cut almost in half from 31 October 2003. This provided an excellent policy experiment as the cut was large, it was binding and it was sudden. If interchange fees were set in a way that induced over-use of credit cards then such a cut in interchange fees would be expected to reduce relative credit card usage. If the interchange fee is essentially neutral then only price changes, not usage changes, would be expected.

This study tests for those potential changes in relative credit card usage by testing for structural breaks. We test for significant changes from the time of the interchange fee reduction in growth in credit card transaction levels, various credit card market shares and in growth of credit card accounts. We perform both exogenous and endogenous break tests. The exogenous structural break tests assume October 2003 as a break point and use binary interaction dummy variable tests. The endogenous break point tests test for one or two structural breaks against a unit root null hypothesis (Lumsdaine & Papell, 1997; Zivot & Andrews, 1992). They involve selecting the break point that is most likely to reject a unit root null in favour of one or two structural breaks.

The results find virtually no evidence for significant decreases in the credit card series associated with the change in the interchange fee, in either the exogenous or endogenous tests. Although the data set is smaller than ideal there was still sufficient power to detect evidence of sensitivity to interest rate change, with increases in general interest rate levels leading to a decrease in relative credit card usage. The endogenous break tests tend to suggest dates associated with interest rate changes. This makes the absence of a decrease in credit card usage at the time of the interchange even more compelling as it was quickly followed by two successive interest rate rises.

The paper outline is as follows. Section 2 provides background information on credit card systems and recent reforms in the context of the neutrality concept. Section 3 explains the empirical approach. Section 4 details the unit root tests and results. Section 5 outlines the tests and results for an exogenous break. Section 6 provides the rationale and results for testing for a single endogenously determined structural break and Section 7 does likewise for tests for two endogenously determined structural breaks. Section 8 discusses the main findings, Section 9 concludes.

2. Background

2.1 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.

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 two-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.

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. 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 historically largely reflected those of other countries, being cooperatively set by the members of the 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).

2.2 Australian credit card reforms

A 2000 study by the Reserve Bank of Australia (RBA) and the Australian Competition and Consumer Commission (ACCC) 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 by MasterCard and Visa that restrict participation in the associations by explicitly requiring card issuers to be authorised deposit taking institutions. 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 shares 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 under a no surcharge rule 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. 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. The result is overuse of the cards compared to a situation where merchants can surcharge for card use.

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.

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, moving from 0.55 percent to 0.5 percent (Reserve Bank of Australia, 2006).

Regulation of the fees would have appeared increasingly likely to the banks over this timeline. 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 willingness of issuers to promote card usage, until the interchange fee actually changed. Furthermore the issuers would have been hopeful of their court challenge obviating the need to tinker with their rewards schemes.

The reforms were successful in their aim getting issuing banks to change the price signals to credit card users. Reports indicated a general reduction in card rewards took place alongside a trend towards increasing annual fees for standard rewards and gold rewards cards, see Figure 2 and Figure 3 (Reserve Bank of Australia, 2008). This response by the issuing banks was both predictable and in fact an intended consequence of the reforms. With a reduced interchange fee the incentive for the banks to encourage each extra dollar of credit card transactions reduced and so rewards programs were expected to be cut. To offset the loss of funding from interchange fees banks were anticipated to increase their recovery of costs via other fees such as annual card fees. This is exactly what happened, and it started to happen relatively rapidly. As early as 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, 2006). Changes noted by the RBA include increases in annual card fees, increases to spending needed to gain rewards and caps to rewards points.

The decrease in the interchange fee was expected to lead to a decrease in the merchant service fee. The RBA reports that for 2007/08 the merchant service fee has fallen by 0.59 percent since the reforms of 2003 (Reserve Bank of Australia, 2008). This is slightly larger than the decline in the interchange fee itself, so the margin of the merchant service fee over the interchange fee has decreased slightly since 2003, see Figure 4. It is plausible that modifications to honor all cards rules, the potential for entry by non-banks and the advent of surcharging have increased bargaining power for merchants over service fee levels.

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.

2.3 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 and that this in turn would reduce any over provision of credit card payment services and under provision of alternative payment methods (Reserve Bank of Australia, 2001). The inference from this is that the level of the interchange fee was expected to significantly affect 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 the credit card interchange fees 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) provide 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 RBA implementation of surcharging would remove the need to mandate the credit card interchange fee (Gans & King, 2003a, 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 evidence so far suggests that the use of the surcharging option is growing. The RBA have highlighted the wide range of industries where surcharging has actually occurred, even in the early days of surcharging being permitted.[5] This provides some indication that merchants are not overly constrained from using surcharging. In addition the RBA reports that there has been strong growth in surcharging in recent years even if the majority of merchants do not surcharge. They report surveys indicating just over one third of very large merchants imposing a surcharge on at least one credit card accepted and a rising rate of surcharging by smaller merchants as well (Reserve Bank of Australia, 2009f). In this context it is worth noting that not all merchants necessarily need to surcharge in order for payment separation to occur and for the interchange fee to be neutral.

2.4 International situation

Interchange fees are a hotly debated regulatory issue around the world. This is at least partly due to competition and transparency concerns. Over 30 countries are reported to have acted or are considering acting in ways such as prohibiting card networks from imposing certain rules on merchants, setting maximum interchange fees, encouraging more institutions to qualify to act as issuers or acquirers and investigating the functioning of payment card markets (U.S. Government Accountability Office, 2009).

Credit card interchange fees are unregulated in the US and their sheer size sparks interest. While total interchange takings are not publicly known, credit card expenditure in the US in 2007 was estimated at 1.9 trillion dollars and typical interchange fees on credit cards are range between 1% and 3% (U.S. Government Accountability Office, 2009). This suggests interchange flows in the US somewhere between 19 billion dollars and 57 billion dollars in 2007 – a large sum even at the lower end of the range.

The GAO report goes on to raise concerns about the level of US interchange fees as well as reservations about other card association rules such as the no surcharge rule, restricting merchants from charging consumers who use a credit card instead of paying by cash or other payment instrument. It is clear from the preceding discussion of neutrality that these issues are potentially strongly interrelated. Unless merchants are able to refuse to accept cards and offer lower prices to consumers then they must charge both cash and card customers the same

[5] 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)

amount due to the no surcharge rule. So cash customers end up paying some of the cost to merchants of accepting cards.

Regulating interchange fees directly could address this issue. However an alternative is to allow payment separation by allowing merchants to surcharge to pass on the costs of card usage to card users. Theory suggests this imparts neutrality on the interchange fee - allowing these surcharges means that the setting of the interchange fee makes little difference to relative card transaction levels. In short surcharging alone might impart sufficient neutrality to the interchange fee that it is not worth regulating the fee.

Even in a less established credit card market with no merchant surcharging allowed, it is not clear that reducing the interchange fee has a negative effect on transaction levels. Spain has experimented with a series of interchange fee decreases (Valverde, Chakravorti, & Fernandez, 2009). They report that Spanish consumers increased their holdings of credit cards even when annual card fees increased in response to the decreased interchange fee. At the same time merchant acceptance increased, from a relatively low base. These two factors probably helped each other. So for a market with an initially relatively low credit card adoption level, their study would suggest that lowering the interchange fee can help develop the market.

Other countries too have seen continued interest in credit card regulation. The European Commission (EC) has accepted July 2009 undertakings from MasterCard to have a maximum cross border interchange fee rate based on savings to merchants from credit card use over cash use (European Union, 2009). The result is a 0.3% cross border interchange fee for consumer credit cards, down from a range of 0.8% to 1.9% in 2007. Many other countries have also initiated changes to no-surcharge rules. For example, in New Zealand the Commerce Commission has reached agreement with MasterCard and VISA so that, among other things, merchants are now permitted to surcharge credit cards. Canada’s Senate Standing Committee has recommended that no-surcharge rules be repealed, though the recommendation is yet to be enacted.

3. Empirical approach

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

At a more general level it also provides a forum for testing whether Australian credit card usage is sensitive to interchange fee levels. If so then it is susceptible to higher interchange fees that can lead to over-use of credit cards (Rochet & Tirole, 2002). If not, then the interchange fee is neutral in the sense of Gans and King (2003a). 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 - cash, cheques, debit cards and charge cards. In this scenario we would expect a reduction in credit card transaction value relative to debit cards, cash, checks and charge cards.

With the dramatic lowering of the average interchange fee from 0.95 percent of transaction value to 0.55 percent on 31 October 2003, we test for structural breaks in the relative use of credit cards. The following sections provide details of tests to determine if this was associated with a structural break in credit cards use. 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 market shares and credit card account growth rates?*

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. While these results do show breaks, albeit positive, stationarity concerns do not allow definitive findings for some series. So we proceed to test for endogenously determined break points as well. We test for a single endogenously determined break using the methodology of Zivot and Andrews (1992) then test for two endogenously determined structural breaks using the method of Lumsdaine and Papell (1997).

3.1 Data

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. The credit card data refers to purchases not cash advances. The change in logs of the credit card transaction value and credit card account numbers are indications of the growth rate. Although the growth rate of the credit card transaction value is somewhat informative, we place more emphasis on the market share series. This is because the market share results indicate the effect of the change in the interchange fee on the relative use of credit cards versus other payment instruments. Changes in the growth rate of credit card transactions could be caused by changes in overall economic activity. The market share results more directly indicate changes away from credit cards towards other payment instruments, rather than effects brought upon by changes in overall economic activity.

Credit card market share is calculated with reference to credit and charge cards, to credit and debit cards and to credit, debit and charge cards. These alternative card payment methods represent the closest competitors for credit cards and are where any anticipated payment method substitution might be expected to most readily occur.

We also calculate market shares based on three broader markets. The first is the point of sale (POS) market. It is the combined cards market plus ATM cash withdrawals and credit card cash advances. This is an approximation of the payment instruments most in use in Australia at the point of sale. The second market is the "convenience" payment market. It includes all of the POS market plus customer cheques, direct credit and direct debit. In this market, credit cards are a small player by value, reflecting the much larger average size of cheques, direct credit and direct debit payments (Reserve Bank of Australia, 2009f). The third market is a simple comparison of credit card transaction value with the total household final consumption expenditure in Australia. Not all credit card expenditure is undertaken by households so this is an imperfect comparator. Still it provides a different indication of the relative growth in credit cards transaction value.

While statistics for the payment methods are generally good there are some limitations. Cash transactions, for example, are not fully recorded and there is no time series data covering all cash transactions. To the extent that there is a stable relationship between cash withdrawals and cash transactions, the flow of cash withdrawals provides an imperfect proxy for the lower bound of the flow of cash transactions (Reserve Bank of Australia, 1998). We use a proxy of ATM cash withdrawals plus credit card cash advances. For 2008/09 the RBA estimates that these two sources account for 68% of cash withdrawals, with bank over the counter withdrawals and EFTPOS cash withdrawals at merchants making up the remainder (Reserve Bank of Australia, 2009f). While we could assume this split stays steady over time we have instead simply limited our cash withdrawal series to the elements with good time series data.

The other key limitation is due to major revamps of payments system data collection. Due to reporting changes the timeframes tested end in February 2008. In January 2002 a major revamp of payments system data collection occurred (Reserve Bank of Australia, 2003).[6] So for credit cards and debit cards the data series extends from May 1994 to February 2008 but 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. We note where these occur in the

[6] Many more institutions were added to 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. A much smaller reporting break also occurred in March 2000 when a reporting change by a bank affected the number of credit card accounts.

analysis. For charge cards, cheques and direct debit consistent data is only available from January 2002 to February 2008.

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.

Figures 5 to 12 illustrate aspects of the data series. The underlying data used in constructing these market shares has not been seasonally adjusted. The graphs do suggest some seasonality with some “peaking” in December or January for several of the series. The real credit card purchases series in Figure 5 appears to be seasonal, with a December peak. This seasonality also appears in the January 2002 to February 2008 timeframe. The peak retail season in December would explain this apparent seasonality.

Credit card account numbers generally increase over the time period examined (Figure 6). The increase is driven by credit cards that have 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 small break at the time of the interchange fee decrease, with credit card account numbers recording an increase from October 2003 to November 2003.

Visual inspection of the broader market share graphs suggests a number of things. The share of the total convenience payment market (Figure 7), which includes direct debit, direct credit and cheques, is flatter than the credit card market share for the other broadest markets examined, household consumption (Figure 8) and point of sale (Figure 9), both of which have distinct positive trends. This convenience payment market share is the series most likely to include payments of an investment rather than a consumption nature. It appears that the general relative rise in credit card use is offset by a rise in direct entry payment methods. The June 2007 drop in credit card market share was driven by a large increase in direct entry payments, 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. An alternative explanation is if credit card use or availability was becoming constrained in a harbinger of the global financial crisis to come.

Figure 10, the credit card share of the total card market, also decreases around June 2007, almost four years after the major reforms. This series also has a distinct “saw tooth” 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.

The credit card share of the credit and debit card market is shown in Figure 11. 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 February 2008 series is likely to be more reliably modelled than the extended series.

The credit card share of the credit and charge card market indicate the potential for a small negative structural break of around one to two percentage points of market share around March and April 2004, a few months after the reforms (Figure 12). More visually distinct, however is the slide in the first half of 2007, a few years after the reforms.

3.2 Seasonality tests

The RBA data is not seasonally adjusted. We address potential seasonality by using seasonal dummy variables. This relies on an assumption of deterministic seasonality. Although tests exist for seasonal unit roots, such as those inspired by Hylleberg, Engle, Granger and Yoo (1990) and Dickey, Hasza and Fuller (1984), we are restricted in having only six to seven data points for each month in the primary series. In particular, the primary series have only one to two 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.

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).

Testing for seasonality involved performing a regression for each series on a time trend, a constant and a set of 11 centered monthly dummies:

$$\boldsymbol{y_t = \alpha_1 + \sum_{i=2}^{12} \alpha_i M_{it} + \delta t + \varepsilon_t}$$

Where M_{it} are centered seasonal dummies, =11/12 if the month corresponds to the month i and =-1/12 otherwise, with January as the base month.

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. Where the time trend was not statistically significant the seasonality findings were unchanged if the time trend was dropped.

Due to the potential for serial correlation we used heteroskedasticity and autocorrelation consistent standard errors (Newey & West, 1987). Following the suggestion of Wooldridge (2006) 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 estimates to be robust to more general forms of serial correlation.

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

Testing for seasonality in the growth rate of the credit card accounts series was problematic. It was the only series where diagnostic tests suggested serial correlation was not a problem. The resulting OLS estimation did not suggest strong seasonality. Despite this we will assume seasonality in subsequent tests using the differenced series. The December result indicated a seasonal effect on the growth in credit card accounts. This makes some sense as December is a time likely to inspire the need or desire for a new account. So we will assume seasonality for this series due to a reasonable belief that opening new credit card accounts could easily be seasonal, the seasonality apparent for the series in December, the seasonality indicated by the extended series and the strong seasonality in the other series. Our later findings of strong positive breaks in this series at October 2003 are not sensitive to this assumption.

As might be anticipated December either features as being significantly greater than the January baseline or is statistically indistinguishable from the January result. The significant results likely reflect the use of credit cards associated with the timing of Christmas, and Australia’s tradition of post Christmas sales and their impact on retail purchases. Where the December result is not statistically significant it tends to be for series affected by the “saw tooth” pattern mentioned previously – perhaps there is a primary sampling artefact at play. In any case we will assume seasonality is important even where December does not have an individually statistically significant result.

4. Unit root tests

Testing for a unit root is used to establish which series, if any, are likely to produce reliable results using Chow type tests for a structural break. We use an augmented Dickey Fuller test and we also test for a unit root versus the alternative of a trend stationary process with a structural break.

4.1 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:

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

$M_{it} = 1$ if the month corresponds to the month i and 0 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 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 by 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 theoretical justification for this procedure and Perron and Vogelsang (1992) for simulation results for 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 use $k_{max} = 12$.

Normally 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 relatively 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.

4.1 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. 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 test regressions are:

$$\boldsymbol{A}: \Delta \boldsymbol{y}_t = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M}_{ti} + \widehat{\boldsymbol{\theta}} \boldsymbol{DU}_t + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{d}} \boldsymbol{DTB}_t + \widehat{\boldsymbol{\alpha}} \boldsymbol{y}_{t-1} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y}_{t-i} + \widehat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{B}: \boldsymbol{y}_t = \widetilde{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widetilde{\boldsymbol{\omega}}_i \boldsymbol{M}_{ti} + \widetilde{\boldsymbol{\beta}} \boldsymbol{t} + \widetilde{\boldsymbol{\gamma}} \boldsymbol{DT}_t^* + \widetilde{\boldsymbol{y}}_t;\ \Delta \widetilde{\boldsymbol{y}}_t = \widetilde{\boldsymbol{\alpha}} \widetilde{\boldsymbol{y}}_{t-1} + \sum_{i=1}^{k} \widetilde{\boldsymbol{c}}_i \Delta \widetilde{\boldsymbol{y}}_{t-i} + \widetilde{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{C}: \Delta \boldsymbol{y}_t = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M}_{ti} + \widehat{\boldsymbol{\theta}} \boldsymbol{DU}_t + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\gamma}} \boldsymbol{DT}_t + \widehat{\boldsymbol{d}} \boldsymbol{DTB}_t + \widehat{\boldsymbol{\alpha}} \boldsymbol{y}_{t-1} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y}_{t-i} + \widehat{\boldsymbol{\varepsilon}}_t$$

Where:

$DTB_t = 1$ 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.

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

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

The t-statistic for α can be compared with the critical values calculated by Perron (1989). The critical values vary with the proportion of the breakpoint to the entire sample, λ, here this point is exogenously given as October 2003. Testing for a break in trend is a two part process where the residuals from the first regression are used to estimate the second regression.

4.2 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. We are unable to reject the null of a unit root at even the 10% significance level for most of the series.

The growth in credit card accounts series did give some evidence towards rejecting the null of a unit root. The market shares are bound by construction and so might be expected to be stationary in the very long run. There is some evidence to indicate the share of the credit and charge market for the primary series rejects the unit root null, without trend at the 10% level. However the tests for other market shares fail to reject the null hypothesis of a unit root.

The Perron tests all failed to reject the null of a unit root at even the 10% level except for the shorter Log credval series for the breaking trend case and the extended growth in credit cards accounts series for the breaking intercept case.

These results in part reflect the low power of the ADF test, potentially exacerbated by the inclusion of seasonal dummies. The apparent lack of stationarity in the credit card market shares may be due to the noticeable “saw tooth” pattern in some of these series. It may also be the result of a large structural break. We note that 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, implying that if a large structural break is responsible for the poor unit root test findings then it is unlikely that the break is at the time of the reforms.

5. Testing for an exogenous structural break

For stationary series, we can use a Chow type test with dummy variables to test for a structural break in the time series data. The preceding unit root test results mean that Chow type test results for most of the series must be treated with caution. However they are still illustrative here. These 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:

$$y_t = \hat{\mu}_0 + \sum_{i=2}^{12} \hat{\alpha}_i M_{ti} + \hat{\mu}_1 DU + \hat{\beta}_0 t + \hat{\beta}_1 (t * DU) + \hat{\varphi}_0 X_t + \hat{\varphi}_1 (X_t * DU) + \hat{\varepsilon}_t$$

Where:

DU is a dummy variable that equals 0 before the interchange fee was changed on 31 October 2003 and equals 1 after that date.

X is an independent variable.

t is time.

M_{it} are 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.

We test the null hypothesis of no structural break using this binary variable interaction regression. Under the null hypothesis of no break:

$\boldsymbol{H_0 : \mu_1 = \beta_1 = \varphi_1 = 0}$

Under the alternative there is a break and at least one of these 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.

5.1 Results

Results from the structural break tests are given in Table 5. The results should be treated with caution due to the lack of evidence against several of the series having a unit root. It is possible that alternative modelling strategies could uncover different processes. The results are provided on the basis that some of the series had some evidence against a unit root null, several of the series could be expected to have long run stationarity and the low power of the ADF tests means that some of the series may have been mis-classified as unit root processes. The results also provide interesting indicative results on the effects of interest rates.

The three series with the best evidence against a unit root, Log credval, Δ Log credaccts and credit card share of credit and charge cards, all had statistically significant positive values associated with the break dummy. The key result here is that there is no support for an

October 2003 break point negatively affecting the credit card series tested. Most of the series have indicative positive breaks at October 2003.

The single exception to the positive break findings is the Δ Log credval series. The coefficient on the intercept dummy is negative but not significant even at the 10% level. As discussed earlier the growth rate in credit card transactions can be influenced by the overall level of economic activity. We prefer the results associated with market shares, as they are expected to be more reflective of movements between payment instruments.

The pre break interest rate results indicated that growth in credit card transaction value was negatively related to interest rate changes. That is, increases in interest rates tended to have a dampening effect on credit card purchase value. This may indicate that when interest rates rise, 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 generally appears dampened as the interacted variable tends to have a negative sign. A possible explanation is due to the fact that interest rates have only increased over the January 2002 to February 2008 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.

Increases in interest rates also spur statistically significant increases in credit card account growth rates. A speculative explanation is that some 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 declines 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 on credit card account growth rates.

6. Tests with a single endogenously determined break

6.1 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:

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

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. The regression equations:

$$\boldsymbol{A}: \Delta \boldsymbol{y_t} = \hat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \hat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \hat{\boldsymbol{\theta}} \boldsymbol{DU}(\hat{\boldsymbol{\lambda}})_t + \hat{\boldsymbol{\beta}} \boldsymbol{t} + \hat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \hat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \hat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{B}: \Delta \boldsymbol{y_t} = \hat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \hat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \hat{\boldsymbol{\gamma}} \boldsymbol{DT}^*(\hat{\boldsymbol{\lambda}})_t + \hat{\boldsymbol{\beta}} \boldsymbol{t} + \hat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \hat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \hat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{C}: \Delta \boldsymbol{y_t} = \hat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \hat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \hat{\boldsymbol{\theta}} \boldsymbol{DU}(\hat{\boldsymbol{\lambda}})_t + \hat{\boldsymbol{\gamma}} \boldsymbol{DT}^*(\hat{\boldsymbol{\lambda}})_t + \hat{\boldsymbol{\beta}} \boldsymbol{t} + \hat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \hat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \hat{\boldsymbol{\varepsilon}}_t$$

Where:

$DU(\lambda)_t = 1$ if $t > T\lambda$, and zero otherwise, a level dummy;

$DT(\lambda)_t = t - T\lambda$ if $t > T\lambda$, and zero otherwise.

λ is the break fraction, chosen to minimise the one-sided t-statistic for testing $\alpha^i = 0$ $(i = A, B, C)$, critical values from the asymptotic distributions provided by Zivot and Andrews (1992). 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 favorable result to the null and to be most in favour of the trend stationary alternative.

Typically the ends of the series are trimmed as the presence of end points causes the asymptotic distribution of the statistics to diverge to infinity. We followed Zivot and Andrews (1992) and used the largest window possible, after allowing for lags and avoiding endpoints.

Selecting a particular model for a series is not straightforward. Some authors select Model C on the basis that it is the most general. Instead we do not impose a particular model and instead will interpret the results collectively. This is conservative in the sense that it allows the chance of an October 2003 break date under any of the models.

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 for every potential break date. 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 $k_{max} = 12$. 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).

6.2 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.

The credit card transaction and market share 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; within a few months of 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 Δ Log credval levels series results indicated a significant positive break in intercept around January 2006 (Model A) and in intercept and trend around December 2005 (Model C). The credit card share of the credit and charge card market also had a significant negative break at June 2007 (Model A). There is no clear explanation for these dates. They are well after the change in interchange fees. The June 2007 date may be associated with the interest rate rise of August 2007.

A number of series had statistically insignificant break dates in May and June 2003, a few months before the reforms. The Log credval series, the credit card share of the credit and debit market and the credit card share of the POS market all had positive, albeit insignificant, breaks around this time under different models. The credit card share of the convenience market had a negative break in the trend around the same time. Again this was not a statistically significant break.

The Δ Log credaccts series had some suggestion of a potential positive break around September 2003 for the model with an intercept and trend. This date also featured in the extended series, though was not statistically significant there.

As anticipated, December 2001 is an endogenously selected break date for several of the extended series. This was the time of major 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 Log credval series. This is a significant structural break in the growth rate of credit cards purchases.

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

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.

7. Tests with two endogenously determined breaks

7.1 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 single endogenous break unit root 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 (1992) 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 analogous to the Zivot Andrews test. The model setting is:

$$\boldsymbol{CC}: \Delta \boldsymbol{y_t} = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \widehat{\boldsymbol{\theta}}_1 \boldsymbol{DU1_t} + \widehat{\boldsymbol{\gamma}}_1 \boldsymbol{DT1_t} + \widehat{\boldsymbol{\theta}}_2 \boldsymbol{DU2_t} + \widehat{\boldsymbol{\gamma}}_2 \boldsymbol{DT2_t} + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \widehat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{AA}: \Delta \boldsymbol{y_t} = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \widehat{\boldsymbol{\theta}}_1 \boldsymbol{DU1_t} + \widehat{\boldsymbol{\theta}}_2 \boldsymbol{DU2_t} + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \widehat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{CA}: \Delta \boldsymbol{y_t} = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \widehat{\boldsymbol{\theta}}_1 \boldsymbol{DU1_t} + \widehat{\boldsymbol{\gamma}}_1 \boldsymbol{DT1_t} + \widehat{\boldsymbol{\theta}}_2 \boldsymbol{DU2_t} + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \widehat{\boldsymbol{\varepsilon}}_t$$

Where:

TB1 and $TB2$ are the potential break dates.

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

$DT1_t = t - TB1$ 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 maximum range possible, allowing for lags and endpoints. 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. The break dates are chosen to minimise the one-sided t-statistic for testing $\alpha = 0$ and the null is rejected if it 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. Lagged differences are included as per the Zivot Andrews test of the previous section with an individually selected value of k, the number of lags, for every potential pair of break dates.

7.2 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. June 2003 is associated with positive and significant breakpoints. In the extended credval series several significant breaks are 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 and April 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 these results together are 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 February 2005 has a negative break point, insignificant under model AA and significant under model CA, around the time of the interest rate rise of March 2005. February and April 2005 feature as insignificant breaks for other series.

Allowing for multiple breaks has uncovered further support for a break around at October 2003 in the shorter Δ Log credaccts series. October 2003 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, with all three models rejecting the null of a unit root at the 5% level.

It would appear that the credit card reforms had 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.

The credit card share of the credit and charge card market had significant breaks under Model AA and CA. The June 2007 negative break date common to both of these results is around the time of an interest rate rise in August 2007.

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. September 2002 and May 2007 are the break dates for both models.

The credit card share of total consumption registers significant positive breaks around May 2003 and June 2003 for some models. This series is perhaps the most prone to measurement error as the consumption figures are derived using interpolated figures. Relatively little weight should be placed on this result although it is interesting to note the positive result.

In the cards, credit and debit and POS market share series 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. A number of the models and series instead give May 2003 and August 2003 as insignificant positive break points. Virgin entered the Australian credit card market in mid-May 2003, which may have created a spike in credit card usage at this time (Virgin Money, 2003).

To summarise 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. 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.

8. Discussion

A major set of reforms to the Australian credit card led to a near halving of the interchange fee at the end of October 2003, following an earlier lifting of restrictions on merchant's surcharging. 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.

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. Despite potential concerns over stationarity, Chow type tests for a structural break with an exogenous break date were done. No significant negative break for the credit card transaction or market share series was found in these tests.

Unit root tests allowing for one endogenously determined structural break in the intercept, the trend or both the intercept and trend 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 sometimes coincided 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 interchange fee reduction was immediately followed by successive interest rate increases in November 2003 and December 2003. The combination of a near halving of the interchange fee and successive interest rate rises was not sufficient for October 2003 to register as an endogenously determined negative break date.

October 2003 did coincide with an increase in the intercept of the credit card account growth rate series. 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 exogenous break 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. Interest rate rises were also associated with increases in the growth rate of credit card accounts. We surmise that some people use a new account to address short term credit constraints and that this practice is more common at the time of interest rate rises. This practice also appears to have reduced after the reforms. We attribute this to the increased fixed cost of credit card accounts, in the form of increased annual fees, making it more expensive to buy another credit card to use for short term cash flow issues brought on by interest rate rises.

The market share tests were done on a range of markets, from quite narrow markets eg credit and charge cards, through to market shares of total household consumption expenditure. Even the credit card market share of credit cards and arguably their closest substitute, charge cards, consistently failed to find evidence of a negative structural break at the time of the reforms.

It could be argued that structural breaks simply could not be found due to low power of the tests. While the sample size is smaller than ideal, and seasonality potentially reduces the power of ADF type tests, it is not clear that simple lack of power is responsible for the credit card reforms failing to appear as significant negative breaks in any of the tests for any of the series tested. Although some of the series - credit card share of credit and debit cards, credit card share of the combined cards market and credit card share of the "point of sale" market - never reject the null of a unit root in favour of a structural break, other series do identify significant structural breaks, both positive and negative. This is particularly around the time of interest rate changes, with breaks tending to be in the opposite direction to interest rate changes. That is interest rate increases tended to be associated with relative declines in credit card usage. However even followed closely by two successive interest rate increases the time of the credit card reforms did not occur as negative structural breaks.

Instead the econometric evidence indicates that the significant credit card reforms, coupled with two interest rate rises, were simply not associated with significant negative breaks in credit card transaction growth rates and market shares. This in turn implies that the interchange fee 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. Once a credit card market is well established it may behave less like the two-sided market definition 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 high consumer and merchant acceptance, has proved to be very resilient to a major price distribution shock.

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.[7] Theory would suggest that the apparent interchange fee neutrality was triggered by the no surcharging rules that were removed some months before the interchange fee was changed, giving merchants time to prepare and implement strategy regarding adoption of surcharging. The prior removal of the rules would have facilitated the payment separation suggested as necessary for interchange fee neutrality by theory (Gans & King, 2003a).

We make no direct comment on the desirability of the reforms for the purposes of redistributing the costs of credit card use. It appears that the reforms have had the effect that credit card users are bearing more of the costs of using credit cards directly via annual fees and merchant surcharges. However this has not appeared to cause 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. Similarly we make no attempt to try and analyse if the reduction in interchange

[7] Note though that a recent assessment of the Spanish reforms of 1997-2007 does not provide support for the lowering of interchange fees having a negative effect on merchant or consumer adoption of credit cards during that market's development from a relatively low base (Valverde et al., 2009).

fees leading to reduced merchant service fees has flowed through to general reduction in the price level. It would seem doubtful that such a response could be successfully isolated.

We note that the reforms may have had some offsetting benefits for credit card users in the form of reduced merchant resistance to credit card use. The merchant service fee has fallen slightly more than the interchange and merchants are able to surcharge credit card use. These factors would be expected to make merchants more welcoming of card use. To the extent that this has increased merchant acceptance of credit card use, even if sometimes surcharged, this benefits credit card users who value widespread acceptance of credit cards by merchants.

In any event the advantages of credit cards – ease of use, access to credit, widespread acceptance by merchants – appear to have maintained consumer attraction for the use of credit cards, even as annual fees have increased and rewards have diminished in response to the reduced interchange fee.

9. 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.

This analysis suggests there is a reduced case in Australia 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. Interestingly in 2009 the Australian Payment Systems Board suggested that regulation of the interchange fee might be removed subject to a series of industry moves towards enhancing competition and voluntary interchange restraint (Reserve Bank of Australia, 2009f). While the industry response was insufficient for direct regulation to be removed the Board has agreed to defer consideration of any further reduction of the interchange fee.

This analysis is also relevant for policy makers around the world, such as those in the US, pondering credit card rule reforms that frequently hinge on directly or indirectly changing the interchange rate. In particular it is a piece of evidence that the removal of no surcharge rules may be sufficient to subsequently reduce concerns about the interchange fee level. Monitoring and regulating the interchange fee under any sort of cost-based regulatory mechanism has inherent costs. Even the relatively simple option of mandatory disclosure of the interchange fee level has costs, with reduced prospect of effectiveness if merchants can not choose to surcharge and make those fees more relevant to consumers when they are choosing their payment instrument. Policy makers should consider the alternative of removing no surcharge rules and following up with monitoring of the adoption of the surcharge option by merchants. Theory and the Australian experience suggest that even partial adoption of the surcharge option by merchants reduces the sensitivity of credit card usage to the interchange fee, thereby reducing the need to closely regulate the interchange fee or to force widespread publication of the fee.

If there was a strong expectation that allowing surcharging would not actually lead to surcharging, say due to transactions costs, then the situation is murkier. Payment separation might still occur via the evolution of “card only” and “cash only” merchants, in which case we might still anticipate neutrality of the interchange fee. However if there was insufficient depth of competition in the market place it is quite plausible that merchants might not differentiate themselves in this way, leaving no payment separation, and non-neutrality of the interchange fee. While it seems likely that merchants would take up the surcharging option if available, the possibility remains that they won’t, and with it a limited possibility that interchange fee regulation could be effective. While Australia has seen good take up of the surcharging option it is not clear if this would necessarily be the case in the US or other countries. If surcharging is ultimately not embraced by merchants, then the option of more direct regulation in the form of interchange fee constraints remains available.

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Figure 1 Flow of exchanges in credit card transactions

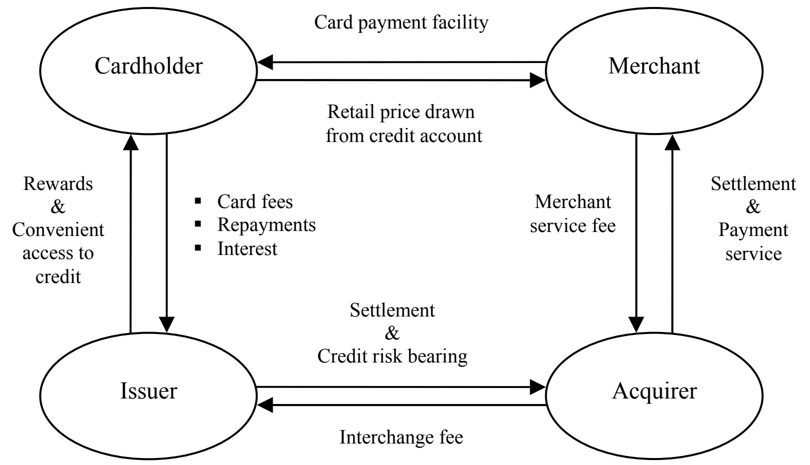
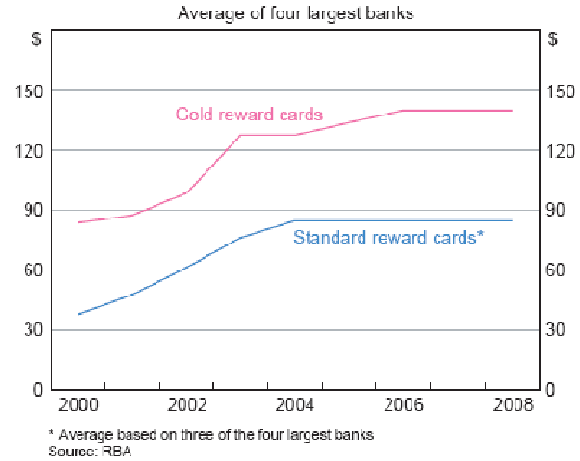


Figure 2 Credit card annual fees



Source: Reserve Bank of Australia (2008)

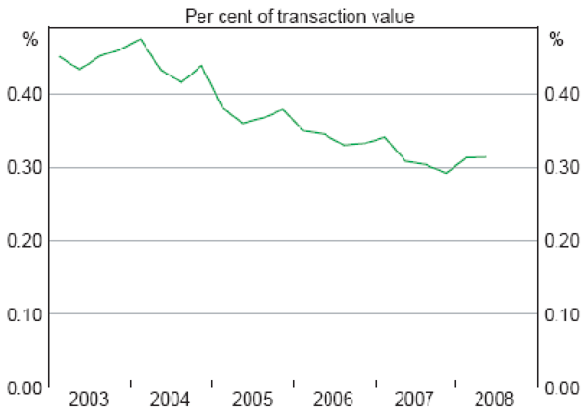
Figure 3 Credit card rewards programs

Four largest banks, June 2009

	Average spending required for $100 voucher	Benefit to cardholder as a proportion of spending (%)
2003	$12 400	0.81
2004	$14 400	0.69
2005	$15 100	0.66
2006	$16 000	0.63
2007	$16 300	0.61
2008	$16 700	0.60
2009	$17 000	0.59

Source: Reserve Bank of Australia (2009f)

Figure 4 Credit card merchant service fee margin over interchange fee



Source: Reserve Bank of Australia (2008)

Figure 5 Real credit card purchases

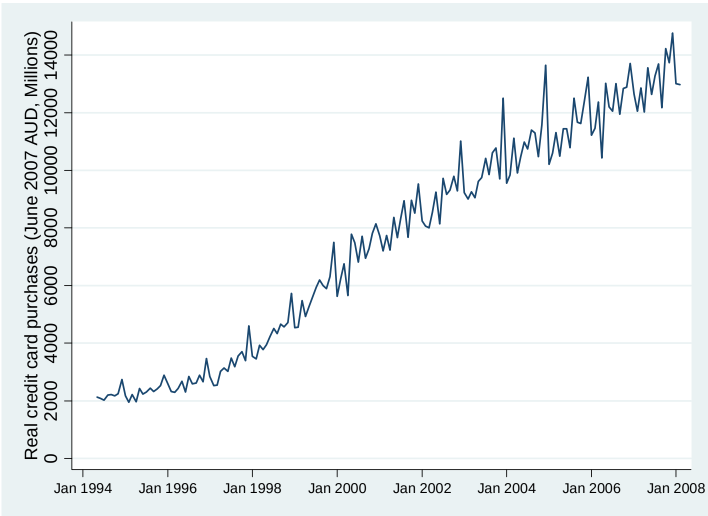


Figure 6 Credit card account numbers

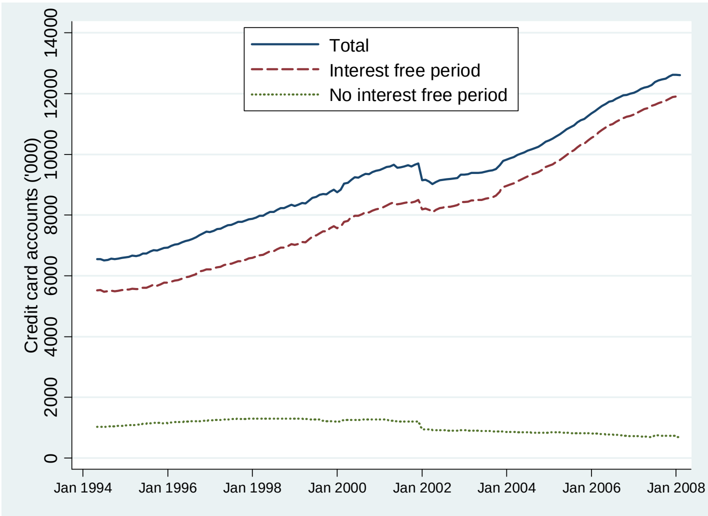


Figure 7 Credit card % share of “convenience” payment market

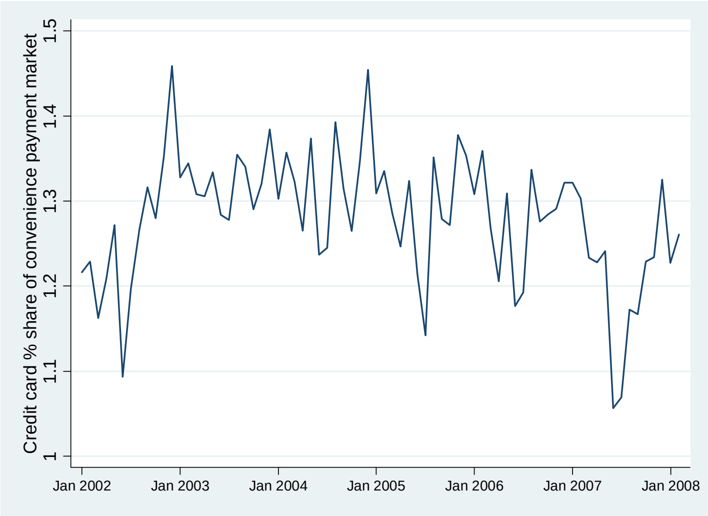


Figure 8 Credit card % share of household consumption

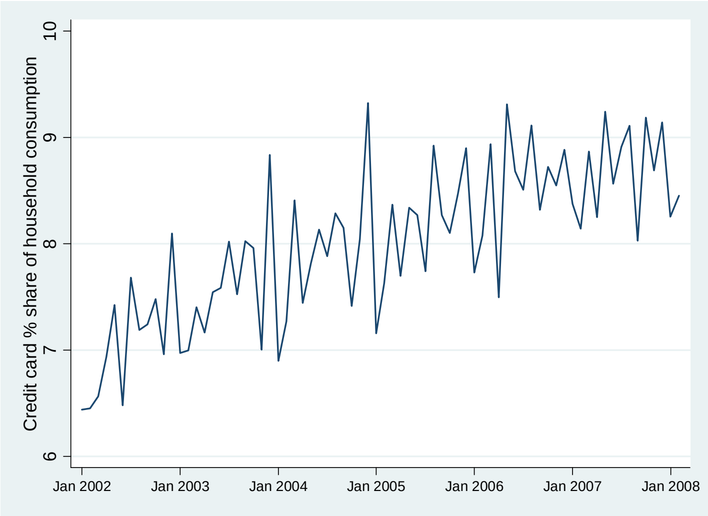


Figure 9 Credit card % share of “point of sale” payment market

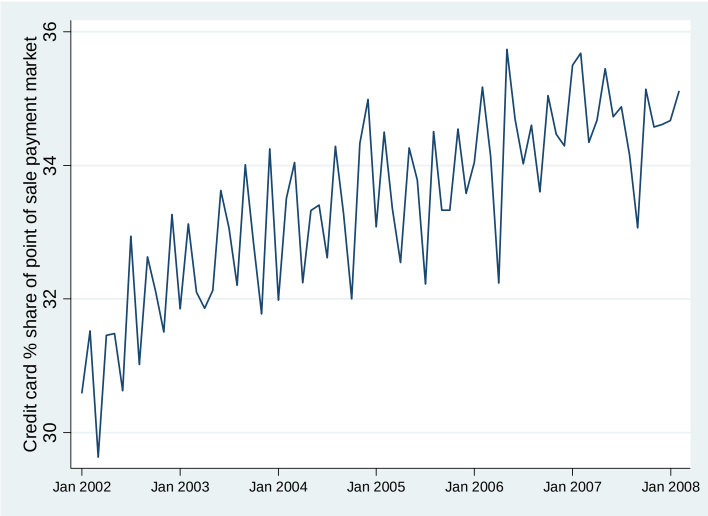


Figure 10 Credit card % share of cards market

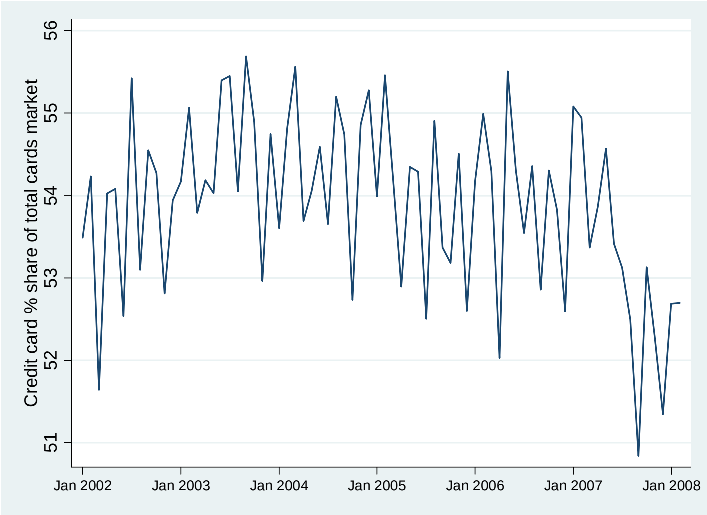


Figure 11 Credit card % share of credit & debit card market

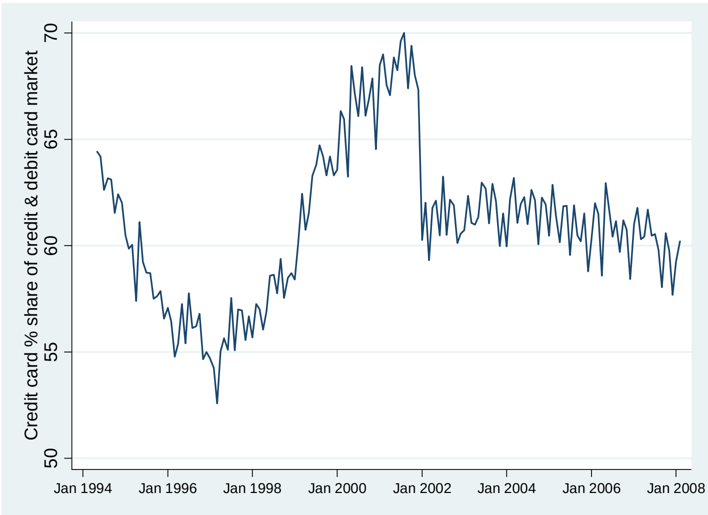


Figure 12 Credit card % share of credit & charge card market

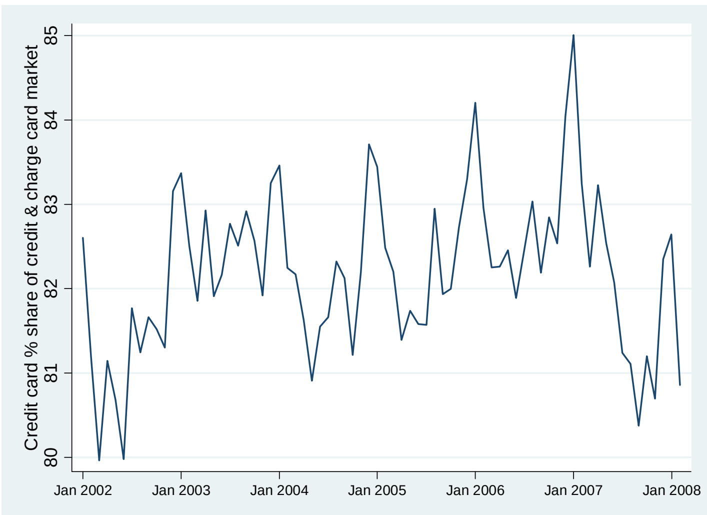


Table 1 Variables & Definitions

VARIABLE	FULL NAME	DERIVATION[a]	SOURCES
Credval	Credit card transaction value (millions of June 2007 AUD)	Total real value of purchase transactions using credit cards, based on cards with and without an interest free period. Quarterly CPI data, linearly interpolated to give monthly figures, is used to convert nominal to real.	Australian Bureau of Statistics (2009b), Reserve Bank of Australia (2009a)
Cred / (cred + char)	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.	Reserve Bank of Australia (2009a, 2009b)
Cred / (cred+deb)	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[b].	Reserve Bank of Australia (2009a, 2009d)
Cred / cards	Credit cards % share of total cards market.	Total credit card purchase transaction value divided by the total purchase value of transactions for credit, charge and debit cards[b].	Reserve Bank of Australia (2009a, 2009b, 2009d)
Cred / POS	Credit cards % share of "point of sale" market	Total credit card purchase transaction value divided by the total value of purchase transactions for credit, charge and debit cards[b], and ATM cash withdrawals.	Reserve Bank of Australia (2009a, 2009b, 2009c, 2009d)
Cred / convenience	Credit cards % share of "convenience payment" market	Total credit card purchase transaction value divided by the total value of purchase transactions for credit, charge and debit cards[b], ATM cash withdrawals, direct debit and direct credit and customer cheques.	Reserve Bank of Australia (2009a, 2009b, 2009c, 2009d, 2009e)
Cred / consump	Credit card % share of household consumption	Total credit card purchase transaction value divided by quarterly household final consumption expenditure that has been linearly interpolated to give monthly figures.	Australian Bureau of Statistics (2009a), Reserve Bank of Australia (2009a)
Credaccts	Number of credit card accounts ('000)	Total number of credit card accounts, both with and without an interest free period.	Reserve Bank of Australia (2009a)

a All figures are as at month end.

b 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.

Table 2 Seasonality tests

$$y_t = \alpha_1 + \sum_{i=2}^{12} \alpha_i M_{it} + \delta t + \varepsilon_t$$

Series[a]	$H_0: \alpha_2 = \cdots = \alpha_{12}$ F stat (p-value)[c]	α_{12} (p-value)	δ (p-value)[d]
Jan 2002 - Feb 2008			
Log credval	81.78 (0.000)	0.194 (0.000)	0.00607 (0.000)
Δ Log credval	44.67 (0.000)	0.311 (0.000)	-0.00007 (0.513)
Cred / (cred+char)	17.68 (0.000)	-0.267 (0.247)	0.00709 (0.540)
Cred / (cred+deb)	23.85 (0.000)	-0.348 (0.631)	-0.02232 (0.006)
Cred / cards	4.96 (0.000)	-0.393 (0.549)	-0.01433 (0.187)
Cred / POS	10.99 (0.000)	0.818 (0.168)	0.04850 (0.000)
Cred / convenience	16.29 (0.000)	0.100 (0.000)	-0.00093 (0.262)
Cred / consumption	50.59 (0.000)	1.328 (0.000)	0.02645 (0.000)
Δ Log credaccts[b]	1.18 (0.321)	0.014 (0.002)	0.00009 (0.036)
May 1994 - Feb 2008			
Log credval	14.19 (0.000)	0.200 (0.000)	0.01259 (0.000)
Δ Log credval	44.91 (0.000)	0.345 (0.000)	-0.00007 (0.124)
Cred / (cred+deb)	3.16 (0.001)	0.207 (0.772)	0.01890 (0.181)
Cred / consumption	13.05 (0.000)	0.985 (0.000)	0.04857 (0.000)
Δ Log credaccts	4.73 (0.000)	0.011 (0.014)	0.00000 (0.724)

a p-values in brackets. For all series, except Δ Log credaccts, Newey West standard errors with 12 lags (Newey & West, 1987) are used as testing using a 12 lag Breusch Godfrey LM test, via Stata program bgodfrey, indicated serial correlation for the series (Breusch, 1978; Godfrey, 1978).

b The Δ Log credaccts Jan 2002-Feb2008 series results reported use OLS standard errors as no serial correlation issues identified using Stata command bgodfrey. Although these results do not indicate seasonality we will assume seasonality for this series. This is based on: the extended Δ Log credaccts May 1994-Feb2008 series results suggesting seasonality; all but one month is individually significant at the 5% level; the use of Newey West standard errors would have suggested seasonality. Later findings of breaks for the Δ Log credaccts Jan 2002-Feb2008 series are not sensitive to assuming seasonality.

c January is the baseline month.

d All series tested with time trends. Where time trends were insignificant re-testing without time trends gave qualitatively unchanged results.

Table 3 ADF Unit root test results

$$\boldsymbol{A}: \Delta \boldsymbol{y}_t = \boldsymbol{\alpha}_1 + \sum_{i=2}^{12} \boldsymbol{\alpha}_i \boldsymbol{M}_{it} + \boldsymbol{\delta t} + \boldsymbol{\beta y}_{t-1} + \sum_{j=1}^{k} \boldsymbol{\gamma}_j \Delta \boldsymbol{y}_{t-j} + \boldsymbol{\varepsilon}_t$$

$$\boldsymbol{B}: \Delta \boldsymbol{y}_t = \boldsymbol{\alpha}_1 + \sum_{i=2}^{12} \boldsymbol{\alpha}_i \boldsymbol{M}_{it} + \boldsymbol{\beta y}_{t-1} + \sum_{j=1}^{k} \boldsymbol{\gamma}_j \Delta \boldsymbol{y}_{t-j} + \boldsymbol{\varepsilon}_t$$

	A: Trend and constant		**B: Constant**	
Series[a]	k	$t(\hat{\beta})$	k	$t(\hat{\beta})$
Jan 2002 - Feb 2008				
Log credval	12	-1.115	12	-1.404
Δ Log credval	11	-2.662	11	-2.391
Cred / (cred+char)	12	-2.623	12	-2.918*
Cred / (cred+deb)	8	-1.372	8	0.806
Cred / cards	8	-1.279	12	-0.241
Cred / POS	8	-1.536	8	-1.806
Cred / convenience	3	-3.101	2	-1.046
Cred / consumption	12	-0.565	12	-1.443
Δ Log credaccts	0	-3.474*	0	-3.474**
May 1994 - Feb 2008				
Log credval	12	-0.886	12	-2.438
Δ Log credval	11	-2.748	11	-1.719
Cred / (cred+deb)	12	-2.103	12	-2.135
Cred / consumption	12	-0.729	12	-1.520
Δ Log credaccts	6	-2.866	6	-2.872*

a ***, **, * indicate significance at 1%, 5% and 10% level respectively. For Jan 2002 – Feb 2008 Model A critical values are -4.126, -3.489 and -3.173 for the 1%, 5% and 10% significance levels respectively while Model B critical values are -3.565, -2.921 and -2.596. Similarly for May 1994 – Feb 2008 Model A critical values are -4.022, -3.443 & -3.143 while Model B critical values are -3.492, -2.886 and -2.576. All critical values interpolated from Dickey (1976) via Stata dfuller command.

Table 4 Unit root versus structural break: Perron (1989)

$$A: \Delta y_t = \hat{\mu} + \sum_{i=2}^{12} \hat{\omega}_i M_{ti} + \hat{\theta} DU_t + \hat{\beta} t + \hat{d} DTB_t + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-i} + \hat{\varepsilon}_t$$

$$B: y_t = \tilde{\mu} + \sum_{i=2}^{12} \tilde{\omega}_i M_{ti} + \tilde{\beta} t + \tilde{\gamma} DT_t^* + \tilde{y}_t;\ \Delta \tilde{y}_t = \tilde{\alpha} \tilde{y}_{t-1} + \sum_{i=1}^{k} \tilde{c}_i \Delta \tilde{y}_{t-i} + \tilde{\varepsilon}_t$$

$$C: \Delta y_t = \hat{\mu} + \sum_{i=2}^{12} \hat{\omega}_i M_{ti} + \hat{\theta} DU_t + \hat{\beta} t + \hat{\gamma} DT_t + \hat{d} DTB_t + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-i} + \hat{\varepsilon}_t$$

	Model A: Intercept		Model B: Trend		Model C: Intercept & trend	
Series[a]	k	$t(\hat{\alpha})$	k	$t(\tilde{\alpha})$	k	$t(\hat{\alpha})$
Jan 2002 - Feb 2008						
Log credval	12	-2.39	12	-4.07**	12	-2.78
Δ Log credval	12	-2.80	11	-2.39	11	-1.53
Cred / (cred+char)	12	-2.05	12	-2.43	12	-1.66
Cred / (cred+deb)	8	-0.61	12	-3.17	12	-2.06
Cred / cards	8	0.46	12	-2.52	12	-1.69
Cred / POS	8	-0.53	12	-2.83	12	-2.41
Cred / convenience	2	-3.11	9	-3.50	3	-3.07
Cred / consumption	12	-0.41	12	-2.10	12	-1.21
Δ Log credaccts	11	-1.08	10	-3.44	10	-1.56
May 1994 - Feb 2008						
Log credval	12	-1.15	12	-2.33	12	-1.54
Δ Log credval	11	-2.69	11	-2.66	11	-2.67
Cred / (cred+deb)	12	-2.49	12	-2.73	12	-2.84
Cred / consumption	12	-1.09	12	-2.63	12	-2.90
Δ Log credaccts	6	-3.69*	6	-3.22	6	-3.67

a ***, **, * indicate significance at 1%, 5% and 10% level respectively. Perron lag lengths are determined using t-tests on the coefficients. Maximum lag length was as for the ADF tests. The final value of k was selected if the t-statistic on c_k was greater than 1.60 in absolute value and the t statistic on c_i for $i > k$ was less than 1.60 (Perron, 1989). Significance levels tested against interpolated critical values for each model given by Perron, with λ~0.297 for the shorter series and λ~0.687 for the extended series. For the shorter series the critical values for the 10% and 5% levels respectively are; Model A -3.46 and -3.76, Model B -3.58 and -3.87, Model C -3.86 and -4.17. For the longer series the critical values for the 10% and 5% levels respectively are; Model A -3.50 and -3.79, Model B -3.58 and -3.86, Model C -3.87 and -4.19.

Table 5 Exogenous break tests

$$y_t = \hat{\mu}_0 + \sum_{i=2}^{12} \hat{\alpha}_i M_{ti} + \hat{\mu}_1 DU + \hat{\beta}_0 t + \hat{\beta}_1 (t * DU) + \hat{\varphi}_0 \Delta Int_t + \hat{\varphi}_1 (\Delta Int_t * DU) + \hat{\varepsilon}_t$$

Series[a]	Log credval	Δ Log credval	Cred / (cred+char)	Cred / (cred+deb)	Cred / cards	Cred / POS	Cred / convenience	Cred / consumption	Δ Log credaccts
DU	0.073 (0.000)	-0.029 (0.176)	1.807 (0.006)	1.852 (0.000)	2.223 (0.000)	1.126 (0.004)	0.184 (0.000)	0.392 (0.003)	0.0115 (0.000)
Time	0.009 (0.000)	-0.001 (0.408)	0.116 (0.000)	0.045 (0.093)	0.085 (0.000)	0.107 (0.000)	0.007 (0.000)	0.044 (0.000)	0.0003 (0.014)
Time * DU	-0.003 (0.004)	0.001 (0.403)	-0.119 (0.000)	-0.086 (0.001)	-0.118 (0.000)	-0.068 (0.002)	-0.010 (0.000)	-0.022 (0.002)	-0.0004 (0.001)
ΔInt	-0.133 (0.087)	-0.360 (0.484)	-1.871 (0.034)	-3.014 (0.063)	-3.165 (0.040)	-3.552 (0.004)	-0.136 (0.162)	-1.187 (0.035)	0.0301 (0.000)
ΔInt * DU	0.193 (0.074)	0.484 (0.006)	0.673 (0.547)	3.606 (0.205)	3.143 (0.224)	3.490 (0.107)	0.040 (0.692)	1.798 (0.041)	-0.0272 (0.000)
F test $H_0 : \mu_1 = \beta_1 = \varphi_1 = 0$	14.99 (0.000)	3.18 (0.031)	105.2 (0.000)	18.35 (0.000)	26.88 (0.000)	13.58 (0.000)	14.08 (0.000)	12.00 (0.000)	10.03 (0.000)
N	73	73	73	73	73	73	73	73	73

a All series results are for January 2002 to February 2008. p-values in brackets. For all series, Newey West standard errors with 12 lags (Newey & West, 1987) are used as testing using a 12 lag Breusch Godfrey LM test, via Stata program bgodfrey, indicated serial correlation for the series (Breusch, 1978; Godfrey, 1978).

Table 6 Single endogenous break unit root tests: Zivot & Andrews (1992)

$$\boldsymbol{A}: \Delta \boldsymbol{y_t} = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \widehat{\boldsymbol{\theta}} \boldsymbol{DU}(\widehat{\boldsymbol{\lambda}})_t + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \widehat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{B}: \Delta \boldsymbol{y_t} = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \widehat{\boldsymbol{\gamma}} \boldsymbol{DT^*}(\widehat{\boldsymbol{\lambda}})_t + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \widehat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{C}: \Delta \boldsymbol{y_t} = \widehat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \widehat{\boldsymbol{\omega}}_i \boldsymbol{M_{ti}} + \widehat{\boldsymbol{\theta}} \boldsymbol{DU}(\widehat{\boldsymbol{\lambda}})_t + \widehat{\boldsymbol{\gamma}} \boldsymbol{DT^*}(\widehat{\boldsymbol{\lambda}})_t + \widehat{\boldsymbol{\beta}} \boldsymbol{t} + \widehat{\boldsymbol{\alpha}} \boldsymbol{y_{t-1}} + \sum_{i=1}^{k} \widehat{\boldsymbol{c}}_i \Delta \boldsymbol{y_{t-i}} + \widehat{\boldsymbol{\varepsilon}}_t$$

	A			B			C		
Series[a]	$TB1$	$t(\hat{\alpha})$	k	$TB1$	$t(\hat{\alpha})$	k	$TB1$	$t(\hat{\alpha})$	k
Jan 2002 - Feb 2008									
Log credval	2003m6 ↑	-3.16	12	2004m8 ↓	-4.10	12	2004m7 ↑↓	-3.89	12
Δ Log credval	2006m1 ↑	-5.34***	7	2005m5 ↑	-3.32	12	2005m12 ↑↑	-5.19**	7
Cred / (cred+char)	2007m6 ↓	-4.83**	12	2007m4 ↓	-3.86	12	2006m11 ↑↓	-4.32	12
Cred / (cred+deb)	2003m5 ↑	-2.32	8	2004m9 ↓	-2.87	12	2005m2 ↓↓	-2.97	12
Cred / cards	2007m7 ↓	-3.13	12	2007m5 ↓	-2.30	8	2007m7 ↓↑	-2.81	12
Cred / POS	2003m5 ↑	-2.72	12	2007m5 ↓	-2.73	8	2006m12 ↑↓	-2.93	8
Cred / convenience	2002m8 ↑	-3.81	3	2003m6 ↓	-3.53	3	2002m8 ↑↑	-3.75	3
Cred / consumption	2007m7 ↓	-2.13	12	2006m9 ↓	-2.40	12	2006m4 ↑↓	-3.79	11
Δ Log credaccts	2003m7 ↑	-4.80**	3	2006m1 ↓	-5.25***	3	2003m9 ↑↓	-5.56**	3
May 1994 - Feb 2008									
Log credval	1997m4 ↑	-3.47	12	1999m8 ↓	-5.27***	11	1999m2 ↑↓	-4.76	11
Δ Log credval	1997m3 ↑	-4.88**	11	1997m9 ↓	-3.83	11	2000m6 ↓↓	-6.18***	10
Cred / (cred+deb)	1998m11 ↑	-3.88	12	2000m5 ↓	-3.59	12	2001m12 ↓↓	-4.66	9
Cred / consumption	1998m12 ↑	-2.39	12	2000m6 ↓	-3.98	12	2002m3 ↑↓	-3.29	12
Δ Log credaccts	2003m9 ↑	-3.95	6	2002m1 ↑	-3.40	6	2003m9 ↑↓	-3.89	6

a ***, **, * indicate the selected break $TB1$ is significant at the 1%, 5% and 10% level respectively. 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 potential break, intercept first then trend where applicable.

Table 7 Two endogenous break unit root tests: Lumsdaine & Papell (1997)

$$\boldsymbol{CC}: \Delta \boldsymbol{y}_t = \hat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \hat{\boldsymbol{\omega}}_i \boldsymbol{M}_{ti} + \hat{\boldsymbol{\theta}}_1 \boldsymbol{DU1}_t + \hat{\boldsymbol{\gamma}}_1 \boldsymbol{DT1}_t + \hat{\boldsymbol{\theta}}_2 \boldsymbol{DU2}_t + \hat{\boldsymbol{\gamma}}_2 \boldsymbol{DT2}_t + \hat{\boldsymbol{\beta}} \boldsymbol{t} + \hat{\boldsymbol{\alpha}} \boldsymbol{y}_{t-1} + \sum_{i=1}^{k} \hat{\boldsymbol{c}}_i \Delta \boldsymbol{y}_{t-i} + \hat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{AA}: \Delta \boldsymbol{y}_t = \hat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \hat{\boldsymbol{\omega}}_i \boldsymbol{M}_{ti} + \hat{\boldsymbol{\theta}}_1 \boldsymbol{DU1}_t + \hat{\boldsymbol{\theta}}_2 \boldsymbol{DU2}_t + \hat{\boldsymbol{\beta}} \boldsymbol{t} + \hat{\boldsymbol{\alpha}} \boldsymbol{y}_{t-1} + \sum_{i=1}^{k} \hat{\boldsymbol{c}}_i \Delta \boldsymbol{y}_{t-i} + \hat{\boldsymbol{\varepsilon}}_t$$

$$\boldsymbol{CA}: \Delta \boldsymbol{y}_t = \hat{\boldsymbol{\mu}} + \sum_{i=2}^{12} \hat{\boldsymbol{\omega}}_i \boldsymbol{M}_{ti} + \hat{\boldsymbol{\theta}}_1 \boldsymbol{DU1}_t + \hat{\boldsymbol{\gamma}}_1 \boldsymbol{DT1}_t + \hat{\boldsymbol{\theta}}_2 \boldsymbol{DU2}_t + \hat{\boldsymbol{\beta}} \boldsymbol{t} + \hat{\boldsymbol{\alpha}} \boldsymbol{y}_{t-1} + \sum_{i=1}^{k} \hat{\boldsymbol{c}}_i \Delta \boldsymbol{y}_{t-i} + \hat{\boldsymbol{\varepsilon}}_t$$

	CC			AA			CA		
Series[a]	$TB1$ $TB2$	$t(\hat{\alpha})$	k	$TB1$ $TB2$	$t(\hat{\alpha})$	k	$TB1$ $TB2$	$t(\hat{\alpha})$	k
Jan 2002 - Feb 2008									
Log credval	2004m3 ↑↓ 2006m4 ↑↑	-6.78^{**}	7	2003m8 ↑ 2005m2 ↓	-4.01	8	2004m3 ↑↓ 2005m2 ↓	-7.00^{**}	7
Δ Log credval	2003m6 ↑↑ 2005m8 ↑↑	-6.89^{**}	7	2005m9 ↑ 2006m12 ↑	-5.83	7	2003m6 ↑↑ 2004m8 ↓	-6.09	7
Cred / (cred+char)	2005m12 ↑↑ 2007m6 ↓↑	-5.67	12	2004m12 ↓ 2007m6 ↓	-6.70^{**}	12	2005m8 ↑↑ 2007m6 ↓	-6.93^{**}	12
Cred / (cred+deb)	2004m10 ↑↓ 2006m4 ↑↑	-5.47	7	2003m1 ↑ 2004m1 ↑	-4.19	7	2005m2 ↓↓ 2006m5 ↑	-5.24	7
Cred / cards	2003m5 ↑↓ 2006m12 ↑↓	-5.99	7	2005m4 ↓ 2007m7 ↓	-4.09	12	2007m1 ↑↓ 2003m5 ↑	-5.25	7
Cred / POS	2003m8 ↑↓ 2006m6 ↑↓	-4.84	7	2005m4 ↓ 2007m7 ↓	-3.87	12	2003m8 ↑↓ 2006m4 ↑	-4.82	7
Cred / convenience	2002m9 ↑↓ 2007m5 ↓↑	-8.33^{***}	0	2002m8 ↑ 2007m4 ↓	-5.41	3	2007m5 ↓↑ 2002m9 ↑	-7.50^{***}	0
Cred / consumption	2003m8 ↑↓ 2006m5 ↑↓	-7.34^{***}	7	2003m6 ↑ 2007m7 ↓	-3.78	12	2006m5 ↑↓ 2003m6 ↑	-6.67^{**}	7
Δ Log credaccts[b]	2003m10 ↑↑ 2006m6 ↓↓	-8.36^{***}	10	2003m10 ↑ 2007m11 ↓	-6.30^{**}	3	2006m6 ↓↓ 2003m10 ↑	-8.51^{***}	12
May 1994 - Feb 2008									
Log credval	1997m4 ↑↑ 1999m2 ↑↓	-6.50^{*}	11	1997m4 ↑ 1999m2 ↑	-4.70	11	1999m2 ↑↓ 1996m2 ↓	-6.35	11
Δ Log credval	1997m4 ↑↓ 2000m7 ↓↓	-8.51^{***}	10	1997m3 ↑ 2000m7 ↓	-8.59^{***}	10	1997m4 ↑↓ 2000m7 ↓	-8.60^{***}	10
Cred / (cred+deb)	1997m1 ↓↑ 2001m12 ↓↓	-9.26^{***}	12	1999m2 ↑ 2001m12 ↓	-5.72	9	2001m12 ↓↓ 1996m1 ↓	-6.77^{**}	9
Cred / consumption	1996m5 ↓↑ 2000m1 ↑↓	-4.52	11	1998m12 ↑ 2006m7 ↓	-3.47	12	2002m8 ↑↓ 1999m1 ↑	-4.60	12
Δ Log credaccts	2001m12 ↓↑ 2003m4 ↓↓	-8.59^{***}	4	2001m12 ↓ 2002m3 ↑	-7.57^{***}	6	2001m12 ↓↑ 2002m4 ↑	-7.27^{***}	6

a ***, **, * indicate the selected breaks $TB1$, $TB2$ are significant at 1%, 5% and 10% levels respectively using critical values (Ben-David et al., 2003), updated from the original (Lumsdaine & Papell, 1997). Model CC critical values are -7.19, -6.75 and -6.48 at the 1, 5 and 10% significance levels respectively. 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 potential break, intercept first then trend where applicable.