XV PACIFIC RIM BANKNOTE PRINTERS' CONFERENCE

Thailand
November 2001

LIFE OF POLYMER CURRENCY NOTES – A STUDY

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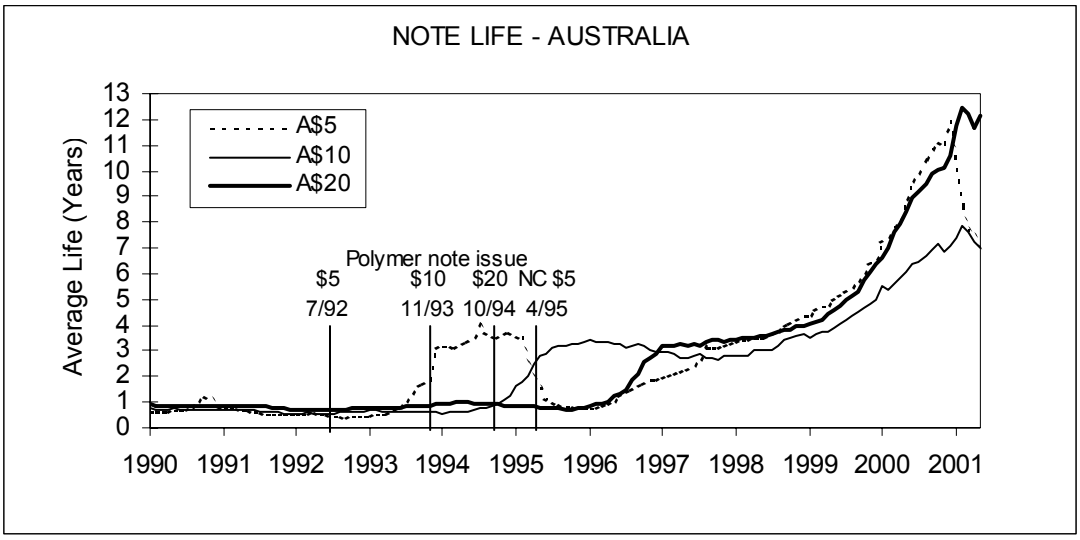
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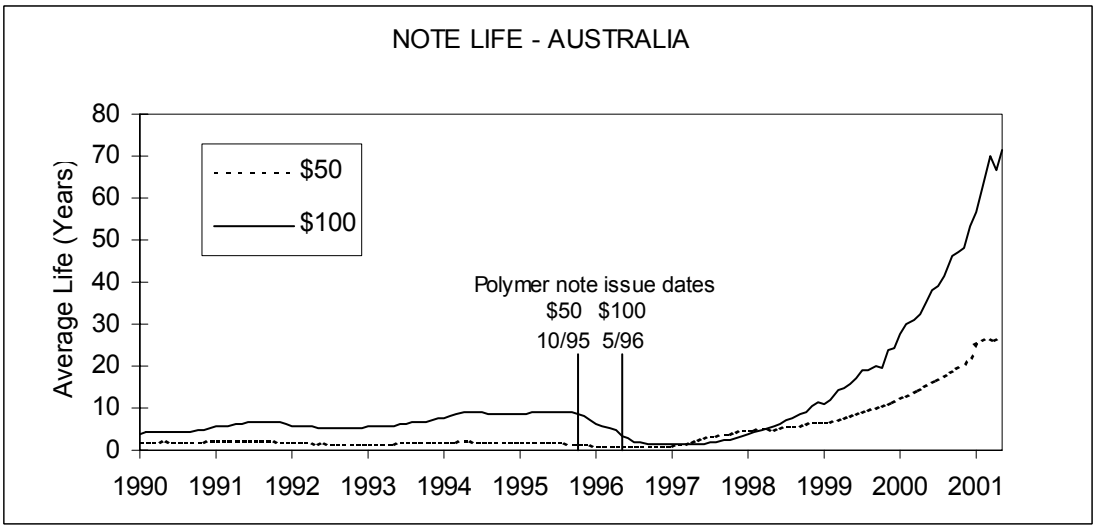
Introduction

Australia's move from traditional rag security paper to *Guardian*® polymer substrate for its notes has resulted in a substantial increase in note life (by a factor of at least four). The ability to translate Australia's experience of increased life to other countries has been questioned by some. This paper examines this issue but first it outlines in some detail the data on life of notes for Australia.

Life of Australian Paper and Polymer Notes

The lives of Australia's notes before and after the conversion from paper to polymer are set out in Graphs 1 and 2.





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Life is defined as:

$$\text{Life (in months)} = \frac{\text{average number of notes in circulation in past year}}{\text{number of notes destroyed in past year}} \times 12$$

The graphs show the impact of a change to a more durable substrate. Consequently, in broad terms, the life for a denomination firstly declines (if the conversion occurs faster than natural attrition) as the older series notes are destroyed. Life then increases as the lower levels of destruction for the new, more durable series, come into the equation. These graphs are based on actual circulation and destruction data over a longer period of time.

Since 1999 changes in distribution and processing arrangements for notes have resulted in fewer notes being destroyed than would normally be expected. This has boosted note life to levels that are higher than we desire, though this will be reversed in future years as the transition to the new distribution and processing arrangements is completed. Under these new arrangements, commercial banks will become largely responsible for the outsorting of unfit notes rather than the central bank.

Translating Australia's Experience to Other Countries

The two main arguments raised to support the contention that the increase in note life experienced by Australia cannot be translated to other countries are that:

- *the lives of most of Australia's previous paper notes were unusually short relative to those of other countries*. Specifically, this is said to be the case for the low to mid-range denominations. This implies that there are very few other countries that had or still have denominations with lives in the six-months to two-year range. If this argument is correct then it implies that either the Australian environment and/or the way Australians handled their notes is more severe than in other countries, that Australia has much higher quality standards for determining if a note is fit for reissue than other countries, or that the quality in terms of durability of the paper substrate previously used for Australia's paper notes was exceedingly poor when compared to that of other countries;

- *potential savings from the added durability of polymer substrate are, in fact, never realised*. This argument is based on the claim that countries will increasingly need to reduce the interval between new series of notes in order to keep ahead of counterfeiters. In fact, it is claimed that the interval between series would become so short that polymer notes would not have completed one life cycle before a further new series of notes was required.

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Life of Notes in Australia Compared to Other Countries

Table 1 includes figures on the lives of paper notes (in months) in 8 of the 13 countries that are represented in the Pacific Rim Banknote Printers Conference[1].

Table 1: Life of Paper Notes (months)

Country	Denom 1 (lowest)	Denom 2	Denom 3	Denom 4	Denom 5	Denom 6 (highest)
Australia	6	8	10	24	96	
Country 1	10	13	15	14	22	
Country 2	16	18	54	102	142	162
Country 3	9	17	26	22		
Country 4	9	12	16	26	30	
Country 5	7	9	13	15	27	
Country 6	8	8	10	19	17	18
Country 7	18	15	18	24	60	112

While only a relatively small sample, it provides an interesting cross-section of countries by size, socioeconomic and environmental conditions, etc. What is clear from the table is that whatever the handling, environmental or quality standards used in these countries, there is nothing unusual about having notes with lives of, say, two years or less. Table 1 shows that:

- all of these countries have between two and six notes with a life of two years or less;
- all of these countries have at least two notes with a life of 18 months or less;
- 75 per cent of all of these countries have at least one note with a life of around 12 months or less; and
- 63 per cent of all of these countries have at least two notes with a life of around 12 months or less.

[1] Data are taken from the statistical survey completed for the XIV Pacific Rim Conference. In that survey five countries did not report life data.

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Consequently, rather than Australia being unique because it had paper notes with relatively short lives, it was at that time, and still is now, quite common for other countries to also have paper notes with relatively short lives.

Paper Quality

Prior to the move to polymer, Australia used wet strengthen, all cotton rag security paper incorporating a mould-made watermark and embedded security thread. Various suppliers were used at different times including Portals, Arjo Wiggins, VHP, and Crane.

The broad specifications that determine durability for the rag paper substrate previously used by Australia were not dissimilar to those of many other countries and, if anything, would be classed as slightly above average based on the advice of the suppliers to the Bank. Table 2 summarises some of the basic specifications for Australia's former paper notes.

Table 2: Australian Paper Specifications

Weight (gsm)	Thickness (microns)	Fold Resistance (MDF)	Porosity (mL/min)	Crumple Porosity (mL/min)	Tensile Strength (N)	Mean Tear Resistance (mN)	Wet Strength Retention (%)
83 +/- 3	100 - 110	3150 (mean MD and CD)	10	150	88 in MD 55 in CD	750	25

MDF – mean double fold; MD – machine direction; CD – cross direction.

There are three important observations that can be made on the data from Tables 1 and 2:

- life varies by denomination with lower value notes having a shorter life than higher value notes;
- most countries have four notes that have an average life of around two years or less;
- the paper quality formerly used by Australia was not noticeably different to that of many other countries.

Therefore, it is hard to see why Australia's experience of achieving significantly greater durability with the move from rag paper to polymer substrate cannot be translated to other countries - maybe not all countries, but certainly most.

To the extent that environmental or handling conditions are more severe in other countries or paper durability or sorting standards are significantly greater, then the increase in life that might be possible with a move to polymer substrate in those countries may be less than that achieved in Australia. However, it is hard to imagine that a significant increase in life is still not attainable.

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Achieving Cost Savings From Added Durability

Typically, circulation (by number of pieces) is dominated by the low to mid-range denominations that are more heavily used in transactions and, therefore, have relatively shorter lives than higher value notes. Consequently, a large proportion of costs of purchasing new notes is related to low to mid-range denominations. The life of these denominations with paper substrate is typically in the six months to two years range. Life for higher denomination paper notes can be as high as 6 to 10 years.

Because polymer substrate is more expensive than paper substrate, but by a factor considerably less than the increase in durability, a move to polymer substrate involves the note issuer in an initial greater outlay. However, this is more than offset over time with cost savings due to the need for fewer notes to replace notes that are unfit for circulation.

The best way of illustrating the potential cost savings from a move to polymer is by way of an example. For simplicity the following assumptions are made:

- that a new series of notes is to be introduced with a choice of using either paper or polymer substrate;
- that there are four denominations (D1, D2, D3, D4) in circulation, each with, say, 100 million pieces in circulation;
- that polymer versions of each denomination last four times as long as the paper version of the same denomination, ie the life of each note is
    - D1 - paper 6 months - polymer 2 years
    - D2 - paper 1 year - polymer 4 years
    - D3 - paper 2 years - polymer 8 years
    - D4 - paper 4 years - polymer 16 years
- that there is no growth in circulation (although this biases the results against polymer) and that the note issuer has a policy of maintaining an inventory of new notes equivalent to, say, six months' issues of new notes as a contingency against supply disruption (many countries maintain higher contingency stocks than this);
- that notes are produced at the beginning of each period and the turnover from the old to new series takes place at the beginning of the first year;
- that the polymer notes cost twice as much as the paper notes (paper notes are given a unit cost of 1 so polymer notes are priced at 2).

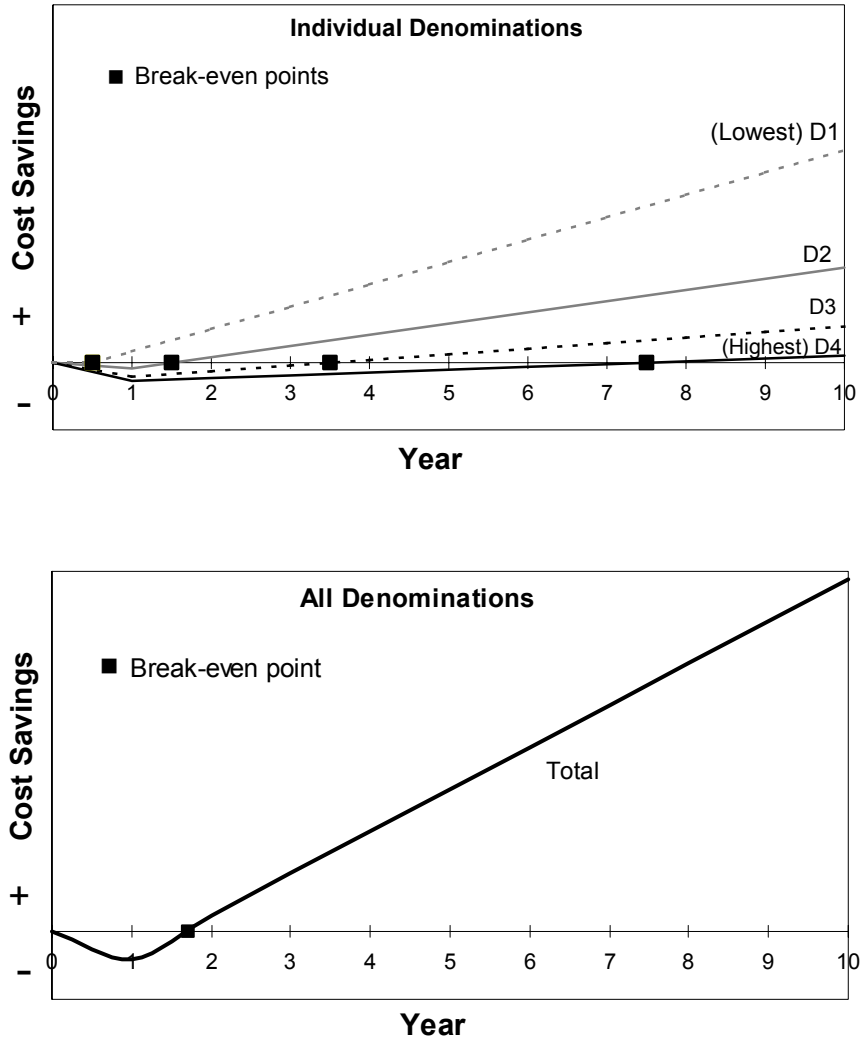
Production requirements at the beginning of year 1 include the turnover stock for circulation, replacement notes for notes that will be destroyed during year 1, and

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the contingency stock. In subsequent years, production requirements will equate to the number of notes destroyed.

Attachment 1 summarises the costs to the note issuer for the different substrates. Graph 3 and 4 plot the cost differential between the paper and polymer options by denomination and for the four denominations in total.

Graph 3: Cumulative Cost Savings of a Move to Polymer



The results indicate:

- the break-even points for the conversion of each denomination to polymer substrate occurs within twice the life of the equivalent paper note i.e. well less than one year for denomination D1 (remembering that the paper version lasted around six months and the equivalent polymer version lasted around two years). Significantly, the break-even points for the low to mid-range denominations occur remarkably quickly;

- the size of the savings are greatest for denominations with relatively low life;

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- once savings start to accrue for the lowest denominations, these savings easily outweigh any higher costs still being incurred for the higher denominations prior to them reaching their break-even points. For example, after just four years the cumulative savings across all denominations exceed the cost of printing a year's supply of paper notes for each denomination. Very importantly, such savings can be much more significant than indicated in Graph 3/Attachment 1 if the circulation volumes (in pieces) for the low to mid-range denominations are greater than those of the higher denominations. As noted earlier this is typical of many countries. For example, all of the 13 countries represented in PacRim have circulations dominated by low to mid-range denominations and most of these notes have lives of two years or less;

- an option that these significant cost savings opens up is that, if desired, the note issuer can use at least part of the savings from the lower denomination notes to pay for added security for the higher denominations. This is true even if the higher denominations, whether printed on paper or polymer, do not stay in circulation for even one full life cycle (see further below);

- even if notes are introduced sequentially rather than all at once, significant savings accrue quickly. Also, if there is a desire to release one or more higher value notes early, then by releasing just one low value note at around the same time or soon after then, again, savings accrue very quickly.

Applying the model described above but using actual life and circulation figures for the eight PacRim members referred to earlier, produces break-even points as outlined in Table 3.

Table 3: Payback Periods for a Range of Countries

Country	Break-even Point
Australia	1 year
Country 1	1 year
Country 2	5 years
Country 3	2 years
Country 4	2 years
Country 5	1 year
Country 6	1 year
Country 7	3 years
Average	Approx 2 years

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Two of the eight countries are often quoted as examples of countries with extremely durable paper substrate. Yet even for these countries the payback periods are only three and five years, respectively. The average break-even point across all eight countries is under two years.

What is the risk that a further new series of notes will be introduced before the savings from a move to polymer are realised? The examples above show that the risk is zero. Significant benefits will accrue very quickly and before the need for a new series even if this was to happen as early as five years after the introduction of polymer. As noted above, most cost savings will come from the lower denominations and the life of polymer low denominations will still be within the likely time cycle for new series. The full potential savings for every denomination may not accrue, but this would also be the case with paper notes as some high value paper notes have a life longer than five years and would have to be prematurely destroyed due to the introduction of the new series.

The Reserve Bank of Australia has never argued that the move to polymer substrate was to achieve added durability for higher value notes. Our decision to use polymer for Australia's currency notes was based purely on improving the security of notes. Added durability, particularly of the lower denomination notes, was a secondary benefit, but one that in the event proved to be very significant. To the extent that the better security of polymer opens up the possibility of longer intervals between new series of notes, then the added durability of higher value notes is an advantage.

A number of further points can be made:

- new series are generally not introduced without considerable lead time and planning including making economical use of existing stocks of notes;

- new series are generally not introduced at times of a single counterfeiting crisis as this can be counter productive;

- claims by paper manufacturers that countries will need to change series every five years to stay ahead of counterfeiters appears to be an admission that paper substrate is losing it effectiveness as a secure substrate;

- it is also unrealistic to assume that every country will be changing its series of notes every five years, as suggested by some paper suppliers, for economic reasons. There will be pressure from note issuers to find better security solutions that make longer intervals between series feasible because the cost to the community, both direct and indirect, of frequent series changes will become unacceptably high. While some countries might go through more frequent changes of series during a period of underlying fundamental change eg after a long period of no change as occurred with the US, or after institutional change such as the creation of the Euro, ongoing, frequent changes in series are not sustainable.

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A more likely scenario than very frequent change in series is that countries will leave their lower denominations unchanged, because they are at little risk from counterfeiting, and 'upgrade' existing higher denomination notes. But, even here polymer substrate offers a clear advantage over paper substrate if countries want to follow this route. This is because, if designed appropriately at the start, an upgrade program based around 'value adding' in the clear window rather than changing the existing printed note design can minimise the cost of change to the community. This happens because machine authentication is largely based around spectral properties of traditional print or covert features such as taggants in inks used for the print.

Also, the paper suppliers who advocate changing series every 5 years have not yet identified new families of security features that can sustain the introduction of a new series of notes every 5 years. At the moment advances in security features from traditional paper suppliers are based around marginal enhancements of old features.

Summary

The Australian data on life shows a significant (at least fourfold) increase in life of notes with the move from paper to polymer. The ability to transfer Australia's experience with polymer notes has been questioned by some. This paper has demonstrably shown such claims cannot be substantiated. It has been shown that the typical profile of circulation in most countries involves large numbers of notes with lives in the six months to two years range. As a result the payback period for a move to polymer substrate is remarkably short and for most countries it will be less than two years[2].

[2] Even if countries decide not to use polymer substrate they can still benefit from polymer because it is only as a consequence of polymer that traditional suppliers are now producing long-life papers, through the use of coatings.

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ATTACHMENT 1

COMPARISON OF CUMULATIVE COST OF PAPER AND POLYMER BANKNOTES

	D1			D2			D3			D4			
Year	Cumulative Cost Paper	Cumulative Cost Polymer	Difference	Cumulative Cost Paper	Cumulative Cost Polymer	Difference	Cumulative Cost Paper	Cumulative Cost Polymer	Difference	Cumulative Cost Paper	Cumulative Cost Polymer	Difference	Total Difference (D1 to D4)
1	400	350	**50**	250	275	**-25**	175	238	**-63**	138	219	**-81**	**-119**
2	600	450	**150**	350	325	**25**	225	263	**-38**	163	231	**-69**	**69**
3	800	550	**250**	450	375	**75**	275	288	**-13**	188	244	**-56**	**256**
4	1000	650	**350**	550	425	**125**	325	313	**13**	213	256	**-44**	**444**
5	1200	750	**450**	650	475	**175**	375	338	**38**	238	269	**-31**	**631**
6	1400	850	**550**	750	525	**225**	425	363	**63**	263	281	**-19**	**819**
7	1600	950	**650**	850	575	**275**	475	388	**88**	288	294	**-6**	**1006**
8	1800	1050	**750**	950	625	**325**	525	413	**113**	313	306	**6**	**1194**
9	2000	1150	**850**	1050	675	**375**	575	438	**138**	338	319	**19**	**1381**
10	2200	1250	**950**	1150	725	**425**	625	463	**163**	363	331	**31**	**1569**
11	2400	1350	**1050**	1250	775	**475**	675	488	**188**	388	344	**44**	**1756**
12	2600	1450	**1150**	1350	825	**525**	725	513	**213**	413	356	**56**	**1944**
13	2800	1550	**1250**	1450	875	**575**	775	538	**238**	438	369	**69**	**2131**
14	3000	1650	**1350**	1550	925	**625**	825	563	**263**	463	381	**81**	**2319**
15	3200	1750	**1450**	1650	975	**675**	875	588	**288**	488	394	**94**	**2506**
16	3400	1850	**1550**	1750	1025	**725**	925	613	**313**	513	406	**106**	**2694**