Price Clustering in the FX Market:

A Disaggregate Analysis using Central Bank Interventions*

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Abstract

Price clustering is a well-documented regularity of foreign exchange transactions. In this paper, I present new empirical results of price clustering for central bank interventions. The empirical analysis for Swiss interventions uses a disaggregate approach. The most important determinants for Swiss National Bank (SNB) transactions are bank size and transaction volume. A further feature of the price clustering of SNB transactions is market dependency. Evidence of clustering in the broker market is considerably smaller than in the dealer market. No single hypothesis of price clustering is able to account for the empirical results.

Keywords: Central Bank Interventions, Intraday Data, Clustering
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Introduction

Price clustering is a well-documented regularity of foreign exchange transactions. Sopranzetti and Datar (2002), Grossman *et al.* (1997), and Goodhart and Curcio (1991) find that indicative quotes for currencies end mostly with either a 'zero' or a 'five'. Goodhart and Figliuoli (1991) observed that round numbers are disproportionately represented in bid-ask spreads for major currencies. Osler (2000) notes that published support and resistance levels used for technical analysis of the major currencies are frequently numbers that end in zero or five. In a later study, Osler (2003) documents strong evidence of price clustering in currency stop-loss and take-profit orders.

This paper's objective is to extend the price clustering analysis in the foreign exchange market to central bank interventions. More specifically, the question that I ask is do central bank interventions suffer from clustering behavior? This query is relevant for several aspects of international finance. One area concerns whether price clustering is consistent with the central banks' intentions for foreign exchange interventions. Although the intervention literature summarized by Edison (1993) and Taylor and Sarno (2001) is silent on the issue of price clustering and central bank intervention, Grossman *et al.* (1997) and others have identified price clustering with increased mar-

ket volatility through larger spreads. If so, then price-clustered interventions may amplify uncertainty rather than instill the intended calm in the FX markets. Indirect evidence that central bank interventions generate heightened exchange rate volatility is offered by Dominguez (1998). Alternatively, Osler (2000) shows that exchange rates tend to reverse course at round numbers. This may be desirable from the central banks' perspective, if the intention is to disrupt trends in the FX market. Such behavior is consistent with the noise channel proposed by Hung (1997).

Market microstructure issues offer a further motive for examining whether price clustering is associated with central bank interventions. Previous studies have offered various hypotheses to explain the rounding phenomena. One is the so-called market power hypothesis. It says that large banks in the dealer market exercise considerable influence in the price setting process and thus are responsible for the clustered activity. Alternatively, the efficiency or the price resolution hypothesis says that transaction size is important. A large transaction motivates incentives to search for better prices. This implies that high volume transactions are traded at finer prices than small volume transactions.

To shed light on these and other microstructure hypotheses, the empirical

strategy in this paper uses a disaggregate approach. This approach is able to determine if price clustering is associated with bank structure (i.e., large versus small banks or foreign banks versus domestic banks), transaction volume, timing, or location. The disaggregated data on central bank transactions are from the Swiss National Bank (SNB). The data have been used in numerous studies, which examine the effectiveness of central bank intervention: Fischer (2003a, 2003b), Fischer and Zurlinden (1999), Paine and Vitale (2003), and Pasquariello (2002). Although the study's focus is on interventions, customer transactions are also used to highlight distinct features between the dealer and the broker market.

The paper is organized as follows. Section one discusses institutional issues and the transactions data used to test for price clustering. Descriptive evidence of price clustering is also offered in the same section. Thereafter in section two, the empirical strategy is defined and the testable implications for the market microstructure hypotheses are specified. The empirical results are presented in section three. Section four concludes with remarks for future research.

1. SNB Transactions in the FX Market: 1986 to 1995

The empirical analysis considers two types of SNB transactions: foreign exchange interventions and customer transactions. Both types of transactions are discussed in detail in the next sub-section. This is then followed by preliminary evidence used to motivate the empirical framework in section three.

SNB Transactions: Some Institutional Features[1]

The SNB intervenes to influence the trend of the exchange rate or to counteract market disturbances. Solidarity with other central banks has also been an important motive in the past because almost all interventions were coordinated. This motive is further underscored by the observation that the scale of the SNB interventions tended to be small and SNB governors have expressed skepticism on several occasions about the effectiveness of such operations. This however does not imply that the SNB has always followed the lead of the Federal Reserve and the Bundesbank. These two central banks have intervened more frequently than the SNB has.

SNB interventions are conducted via telephone correspondence in the dealer market with foreign and domestic commercial banks operating in sev-

[1]Much of this material is taken from Fischer and Zurlinden (1999).

eral Swiss cities.[2,3] The SNB's activity in the dealer market is limited and should not be treated as a marketmaker. SNB interventions are thus based on market exchange rates. It is common for the SNB's trading desk to gather *binding* quotes from commercial banks before executing an intervention transaction.

The SNB communicates its interventions directly with the counterparty. After the intervention transaction has been completed, the SNB informs the trader of the commercial bank that the transaction is an intervention. According to SNB officials, the intervention announcement spreads swiftly across the dealer market. The SNB makes no formal declaration to news agencies that it is intervening. The SNB in most cases will be asked by a newswire service if it has intervened, in which case an SNB spokesman will confirm or refute the intervention claim.

The SNB's intervention strategy may be described as following a shotgun

[2]The major city is Zurich followed by Basel, Geneva, and Lugano. Other locations on a minor scale include Zug and St. Gallen.

[3]Telephone correspondence represents the norm. Neely (2001) in his survey of operational issues for 22 central banks finds that most central banks conduct their interventions through telephone correspondence. Other possibilities include electronic brokers (i.e., Reuters 2002 or EBS) or direct dealing with counterparties via electronic communication.

tactic. An intervention session is characterized by numerous intervention transactions of small volume. The volume per transaction is most often either \$5 or \$10 million.[4] The sessions are generally completed within 10 to 30 minutes. With this tactic, the intervention's news is disseminated in the dealer market.

The second type of SNB transactions is customer transactions.[5] These are purchases of U.S. dollars triggered by the Swiss government's request for foreign currency. If the government needs other foreign currencies, the SNB buys these currencies with U.S. dollars in the market. The government's currency requests thus result in a dollar outflow. In turn, the SNB compensates this outflow by repurchasing U.S. dollars against Swiss francs either directly from small domestic banks or through the BIS.

Customer transactions, as opposed to interventions, are brokered transactions via telephone correspondence. It is thus not the SNB's intention to influence the Swiss franc with these type of transactions. The SNB has some scope in timing the customer transaction. As such, customer transactions

[4]Only on rare occasions was the transaction's size over \$20 million.

[5]This is the term coined by Fischer and Zurlinden (1999). It is somewhat unconventional, because the actual customer transaction is the purchase of (other) foreign currencies for dollars on behalf of the government.

are more likely to be performed when exchange rate volatility is low as opposed to interventions. Further, customer transactions are not split up as are interventions. It is only on rare occasions that the SNB will conduct more than one customer transaction per day. This means they are generally large volume transactions. Under these procedural arrangements (i.e., speed of transaction, counterparty type, transaction volume), it may be expected that customer transactions are less subject to price clustering than are interventions.

Descriptive Evidence of Price Clustering in SNB Transactions

Descriptive evidence of price clustering in SNB transactions is offered to motivate the disaggregate approach. The sample, as in the empirical regressions of section three, is from 1986 to 1995. The sample's size is determined by data availability. The SNB's records for its transactions do not go beyond 1986 and the last SNB intervention was conducted on 15 August 1995.[6]

Table 1 documents the evidence for the last digit of SNB transactions in the CHF/USD exchange rate. The upper half of the table provides evidence for interventions, whereas the lower half is for customer transactions. Price

[6] A further consideration is the definition of customer transactions. Shortly after 1995, the SNB booked differently its customer transactions with the federal government.

clustering is the result of the use of a coarse pricing set in which only a small fraction of the full set of potential prices are actually used. The evidence of price clustering in the odd and even ending digits is not as pronounced as those ending in zero or five. Hence, the analysis will focus on the latter form of clustering.

The evidence of price clustering in zeros and fives is considerably stronger for SNB interventions than for SNB customer transactions. The percentage for total interventions in Table 1 finds that roughly 80% of the transacted exchange rates end in either a zero or a five, whereas for total customer transactions the percentage is 40%. These percentages for the zero and five digits are not as high as the 91% found by Pasquariello (2002) for the CHF/USD exchange rate quotes in the dealer market. Moreover, he finds that the zero quotes (78%) dominate the five quotes (13%) by a margin of six to one, implying that there is clustering for even ending-digits as opposed to odd-ending digits. The evidence in Table 1 does not support such asymmetric behavior of SNB transaction prices.

A further sign of clustering in intervention transactions is that none of the end digits is close to the expected 10% level. The percentages for the digits '2', '3', '7' and '8' lie below 5% followed by the digits '1', '4', '6', and '9',

which border '0' and '5', are even below 1%. This information is consistent with the resolution hypothesis of Ball, Torous, and Tschoegl (1985), which says that price clustering is the achievement of an optimal degree of price resolution.

If the price resolution theory were correct, one would find symmetry between odd and even final digits and that the ranking of the final digits would be 0, 5, (2=3=7=8), and (1=4=6=9). This result is supported by the sign tests for interventions (but not for customer transactions) recorded in Table 2. The result for interventions is at odds with the evidence in Goodhart and Curcio (1991) for exchange rate quotes.

Table 1 also divides the price clustering evidence for interventions into purchases and sales of U.S. dollars. The same cut for customer transactions is not made since all of these transactions are dollar purchases. The results show that the direction of the intervention does not influence the price clustering result.

A further consideration in the regression analysis is to divide the data along counterparty type. Table 1 also shows percentages for Big Banks in Switzerland.[7] The results for the interventions suggest that this feature does

[7]Big Banks is an expression frequently used in Switzerland to denote a select group

not appear to influence the outcome. The percentages between total and Big Banks are in line with each other. Larger differences, however, are observed in the broker market for customer transactions. One potential explanation for the difference is the influence of BIS transactions. Although percentages for the customer transactions with the BIS are not uniform, they do not exhibit the price clustering behavior of high percentages for '0' and '5' marked by extreme low percentages for '1', '4', '6', and '9'.

An issue in many empirical studies is that price clustering varies over time. Gwilym, Clare and Thomas (1998), for example, show that intraday price clustering is strongest during the opening and closing of the futures market for FTSE 100 index contracts. These are the hours when trading is most intense. Figure 1 shows the same intraday information for SNB transactions. The hourly breakdown finds that the zero and the five frequencies are quite stable throughout the day. An exception is the lower clustering frequency of late hour trades in customer transactions. One explanation is the low number of customer transactions in the late afternoon: 68% of the customer transactions were conducted in the morning hours from 8:00 am to 12:00 am

of large Swiss banks. For the analyzed sample they include Union Bank of Switzerland, Credit Suisse, Swiss Bank Corporation, and Volksbank

o'clock.

An alternative form of time variation that influences the degree of price clustering is along the calendar domain. Figure 2 shows annual frequency patterns of the zero and five end digits. The clustering frequency for interventions rises slowly between 1986 and 1992 and is volatile thereafter. The high volatility at the tail end of the sample is marked by the fact that the SNB did not intervene in 1993 and that few interventions were carried out in 1994 and 1995.[8] Also, the frequency of price clustering in customer transactions appears to be time varying. It tends to fall in the years from 1989 to 1994 when the SNB transacted with the BIS.

Whether these descriptive results are conditional on the mentioned factors or others such as transaction volume requires an empirical strategy that is able to handle disaggregate data. This is outlined in the next section.

2. The Empirical Framework

A probit model is used to test competing hypotheses that explain the

[8] Grossman *et al.* (1997) also present evidence of increased price clustering over time. They show an increase in the use of odd-eighth quotes for Nasdaq securities from 1 January 1993 to 31 December 1994.

clustering phenomena of SNB transactions in the CHF/USD currency market. The disaggregated specification defined for interventions is as follows (A similar variant of equation (1) is considered for customer transactions):

$$\begin{aligned} S_t &= b_0 + b_1 BigBank_t + b_2 DomBank_t + b_3 Loc_t \\ &\quad + b_4 Repeat_t + b_5 Time_t + b_6 Vol_t + \epsilon_t, \end{aligned} \tag{1}$$

where the dependent variable, S_t, is +1 if the transacted exchange rate ends in a zero or a five, 0 otherwise. Next, the explanatory variables are defined as follows: $BigBank_t$ is +1 if a Big Bank is the counterparty to the transaction, 0 otherwise; $DomBank_t$ is +1 if the transaction is with a Swiss bank, 0 if it is with a foreign bank; Loc_t is +1 if the counterparty bank is located in Zurich, 0 otherwise; $Repeat_t$ is +1 if the transaction is repeated in the same day, 0 if it is the first intervention; Vol_t is the size of the transaction; and $Time_t$ is the time of the transaction. Last, ϵ_t denotes the error term.

The disaggregate regression (1) is motivated by the desire to test competing hypotheses of rounding for central bank transactions. The negotiation efficiency hypothesis by Harris (1991) and Grossman *et al.* (1997) says that if buyers and sellers are eager to speed up the negotiation process of their

transactions, then they will not quibble over small increments in price. In a similar manner, the central bank in its intervention operations prefers to choose round numbers to minimize time and error in their communication with dealers.[9] Given the design of how SNB interventions are executed, the quick dissemination of news is an important prerequisite for a successful intervention. Once the patterns of communication are established, Osler (2003) argues that rounding may be self-reinforcing even in the presence of rational speculative activity.

For interventions and customer transactions, the efficiency hypothesis says that there should be no observable difference in the timing, type of commercial bank, and location for transactions of the same size. Hence, these variables should not be significant in equation (1). However, as the transaction's volume increases the incentives of the pre-established pricing pattern defined under the efficiency hypothesis diminish. Smaller transactions should thus observe a larger occurrence of rounding (i.e., $b_6 < 0$ in equation (1)), because larger transactions would benefit the most of precise

[9]This evidence would also be supported by the hypothesis that agents prefer certain numbers for purely behavioral reasons, see Yule (1927), possibly because they are easiest to process, cognately.

pricing. Because speed and timing are important features of interventions as opposed to customer transactions, it is expected that the volume impact defined by the efficiency hypothesis is stronger for customer transactions than for interventions.

A further testable hypothesis within the contours of equation (1) is the market power hypothesis with price leadership. Christie and Schultz (1994) contend that market structure matters. In the case of SNB bank transactions, the hypothesis says that certain banks in the dealer market, i.e., Big Banks as opposed to small commercial banks, exercise market power in the setting of prices. Price leadership through asymmetric information is one possible channel that defines market power. Peiers (1997) and Sapp (2002), for example, find that Deutsche Bank is the price leader in periods of uncertainty around central bank intervention. Dominguez (2003) also finds evidence that some traders know one hour in advance to the public release of the information that the Federal Reserve is intervening. One means for Big Banks to conceal such information is to round prices, regardless if the counterparty is another commercial bank or the SNB.[10] It is assumed that the Big Banks seek to mask their transactions as long as possible.[11]

[10]Remember, the SNB is assumed to be a price taker.

[11]See Lyons (2002), a chief tenet of the market microstructure theory of the exchange

Whether this type of market power is associated with clustering can also be tested for the Swiss case through the division of bank type: Big Banks versus domestic banks or foreign banks. Significant and positive coefficients for b_1 or b_2 would thus be consistent with the market power hypothesis.

The noise hypothesis represents a third testable hypothesis. It says that rounding reflects market uncertainty surrounding specific events. Market uncertainty, which varies over time, may stem from the anticipation of specific events, including intervention but not customer transaction, because the latter should not signal any information. This means that at the initial stages of an intervention there is considerable rounding, however as the intervention session unfolds and becomes known in the market the degree of rounding should diminish. Hence, it is the timely dissemination of news and not whether a select group of market participants receive information (as under the market power hypothesis) that matters for the noise hypothesis.

The noise hypothesis says that the coefficient b_4 in equation (1) should be negative for same day interventions but equal to zero for customer trans-

rate is that dispersed information is not rapidly summarized in public information. Evidence of lagged information diffusion for Swiss interventions is offered by Fischer (2003b). He finds that Reuters newswire announcements of SNB interventions do not match well with the transactions data.

actions. Indirect evidence of the noise hypothesis stems from Fischer and Zurlinden (1999) and Payne and Vitale (2003). They show that first-round interventions and not subsequent interventions matter in their tests of the signaling hypothesis. If the noise hypothesis is true, it would imply that interventions have a longer and calming effect than is commonly believed.

3. Empirical Results of Foreign Exchange Clustering

The regression results confirm the descriptive evidence offered in Figure 1 and Table 1. The clustering result with SNB transactions holds for the dealer and the broker market, however the importance of the transaction's attributes differs across markets. This means that no single hypothesis is consistent with the regression results.

Table 3 summarizes the regression results for SNB interventions. The analysis depends on disentangling the directional effects of transaction's characteristics on price clustering. For example, a negative coefficient for the volume variable, β_6 in equation (1), suggests that increasing volume size will decrease the probability of price clustering in SNB transactions; a positive value implies the opposite.

The main observations are the following. First, location, timing, and

repeated interventions are not statistically significant in the different variants of equation (1). This suggests that the market's geographical location is not associated with rounding. The evidence is also interpreted as such that uncertainties pertaining to the market's knowledge of an intervention has no bearing on the clustering behavior, i.e., the insignificance of the variable $Repeat_t$ is not consistent with the noise hypothesis.[12]

A second observation is that as intervention volume increases so does clustering in the final zero digit. This variable is positive and significant for the final zero digit, but negative and insignificant for the five digit. The combined impact for the zero and five digits is also positive and significant. Sopranzetti and Datar (2002) find similar evidence for indicative quotes for six currencies against the US dollar. This result for Vol_t is not consistent with the efficiency hypothesis, which would expect a finer price setting to occur as intervention volume increases.

An open issue is whether the positive correlation between intervention volume and clustering arises from increased intervention intensity. In this case, a positive correlation and not a negative correlation would still be con-

[12]This result is also true for alternative definitions of $Repeat_t$, i.e., +1 after 5 minutes after the first intervention.

sistent with the efficiency hypothesis, because greater intervention activity requires greater speed in transacting. Three checks were carried out. The first test was to determine if the positive correlation held even after dropping the three intervention days in which the SNB intervened on its own. This meant dropping 67 observations from the sample's 706. The second was to rerun the regression of the first check but without the first intervention for the 63 intervention days. The third was to discard days when intervention volume exceeded the sample's median of $100 million; i.e., 23 intervention days. For all tests, no change in the coefficient's sign was observed. This confirms the view that the efficiency hypothesis is inconsistent with price clustering in SNB interventions.

The third observation drawn from Table 3 regards the influence of bank structure on price clustering. The role of Big Banks does not appear to matter, but the domestic bank variable, $DomBank_t$, gives mixed signals. In most regressions for the zero digit, $DomBank_t$ enters negatively and significantly. This would suggest some form of market power for foreign banks. The opposite result holds for the five digit. Here, it is the domestic banks that demonstrate market strength. Whether this difference in behavior reflects alternative practices of strategic pricing between foreign and domestic

banks is a question that cannot be answered. In the case for zero or five digits, the two factors cancel each other.

Next, the comparative results from the broker market using customer transactions are presented in Table 4. The choice of variables is slightly different from those previously discussed in Table 3. The counterparty variable, BIS_t, now defines the bank structure. This is because small domestic commercial banks were primarily the counterparty in customer transactions, except for those with the BIS. This made the location variable redundant, because almost all transactions were conducted with small commercial banks located in Zurich, except those with the BIS in Basel.

The results show that the BIS variable mitigates the degree of price clustering in all regressions. This suggests possibly that the SNB obtains finer price offers through the BIS: a result consistent with the market power hypothesis. Also for all regressions in Table 4, the coefficient for the volume variable is negatively signed. Volume is significant in the final zero digit and the combined case of zero or five. This evidence for customer transactions is consistent with the efficiency hypothesis. As in the case for interventions, the variables capturing timing effects and same day effects are found to be insignificant in most regressions.

4. Concluding Remarks

The paper's contribution is to present new evidence of price clustering in central bank transactions. SNB interventions and to a lesser extent SNB customer transactions exhibit price clustering in the CHF/USD spot market. Despite the recognition that the objectives motivating the central bank transactions differ from those generated by profit-oriented commercial banks, similar pricing properties are observed. The disaggregated approach finds that transaction volume and bank structure are the most important determinants explaining the clustering result, however their directional influence is not stable.

The clustering phenomena observed in central bank interventions re-opens old issues that are left for future research. One is to understand the causal linkages between price clustering, interventions, and market uncertainty. Empirical papers by Dominguez (1998) and others observe that exchange rate volatility increases when central banks intervene. If price clustering in interventions leads to wider bid-ask spreads and thus increases exchange rate volatility, then the task of market microstructure theory is to seek new identifying restrictions that attribute the widening of spreads to market structure or to asymmetric information.

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Figure 1: Intraday Distribution of SNB Transactions

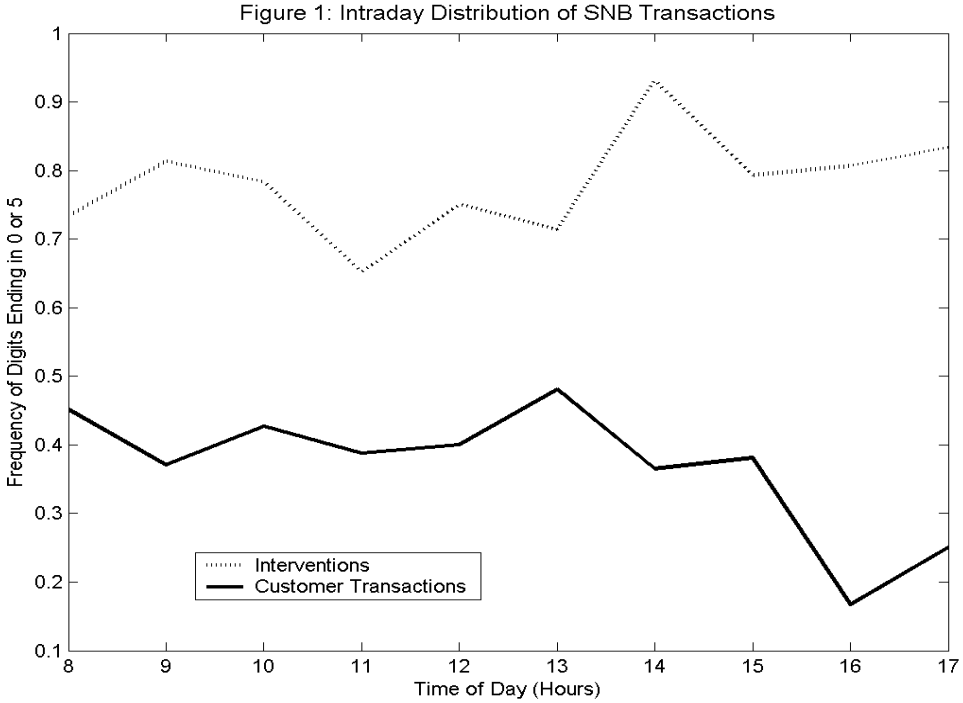

Figure 2: Price Clustering of SNB Transactions from 1986 to 1995

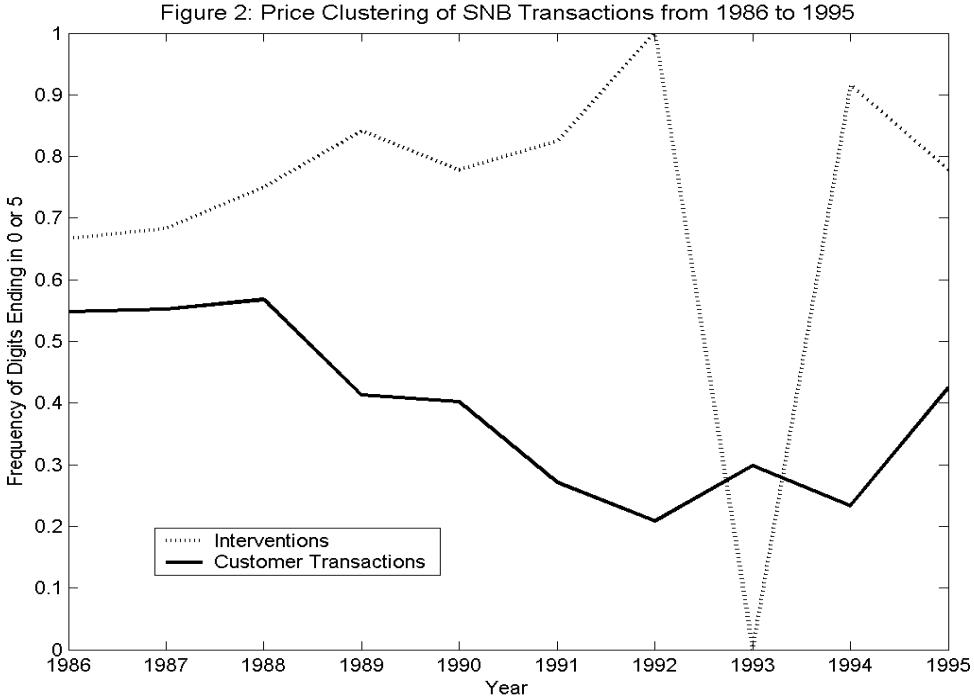

Table 1: Price Rounding in SNB Transactions (in Percent)

SNB Interventions

fourth digit	Total	Dollar Purchases Total	Dollar Purchases Big Banks Only	Dollar Sales Total	Dollar Sales Banks Big Banks Only
0	45.33	38.02	38.30	49.14	50.71
1	0.42	1.24	1.42	0.00	0.00
2	3.68	4.96	2.84	3.02	2.5
3	4.53	4.55	2.84	4.53	3.93
4	0.71	0.00	0.00	1.08	1.07
5	34.41	36.36	41.84	33.41	33.57
6	0.71	0.41	0.71	0.86	1.07
7	4.67	8.68	6.38	2.59	2.86
8	4.82	4.55	4.26	4.96	4.29
9	0.71	1.24	1.42	0.43	0.00
0 and 5	79.74	74.38	80.14	82.55	84.28
Even ticks	55.25	47.94	46.11	59.08	59.64
Odd ticks	44.74	52.07	53.90	40.96	40.36
NOB	706	242	141	464	282

Note: Table continues on next page.

Table 1: Price Rounding in SNB Transactions (*continued*)

SNB Costumer Transactions

fourth digit	Total	BIS	Big Banks Only
0	21.57	13.38	33.99
1	5.23	11.15	0.79
2	8.89	8.6	7.11
3	7.97	7.32	8.3
4	4.05	4.77	0.79
5	17.65	7.01	26.48
6	9.15	15.61	1.19
7	8.63	8.92	10.28
8	10.98	14.01	9.49
9	5.62	9.24	1.58
0 and 5	39.22	20.39	60.47
Even ticks	54.64	56.37	52.57
Odd ticks	45.10	43.64	47.43
NOB	765	314	254

Notes: Price clustering is for fourth digit in the Swiss franc/U.S. dollar exchange rate. NOB refers to number of observations. All values are in percent.

Table 2: Sign-Rank Tests for the Fourth Digit (1986-1995)

Fourth Digit	'0'='5'	'3'='7'	'8'='2'	'4'='6'	'1'='9'
Interventions	0.001	1.000	0.366	1.000	0.727
	(0.001)	(0.901)	(0.302)	(1.000)	(0.547)
Customer Trans.	0.000	0.723	0.224	0.000	1.000
	(0.000)	(0.657)	(0.194)	(0.000)	(1.000)

Notes: Fourth digit is the y digit of the CHF/USD exchange rate 'x.xxxy'. Values are the significance of a 0.01% test of the null hypothesis that the median difference between two matched series is zero. Values given in parentheses are significance levels of the Wilcoxian sign test.

Table 3: Regression Results - Price Clustering of SNB Interventions

Ending in '0'					
Constant	-0.4039	-0.3824	-0.4500	-0.4623	-0.5220
	(0.2367)	(0.2368)	(0.3115)	(0.3125)	(0.4763)
$DomBank_t$	-0.3487	-0.5204*	-0.5182*	-0.5104*	-0.5147*
	(0.2101)	(0.2457)	(0.2458)	(0.2462)	(0.2469)
$BigBank_t$		0.2510	0.2543	0.2434	0.2362
		(0.1851)	(0.1853)	(0.1864)	(0.1871)
$Repeat_t$			0.0730	0.0625	0.0713
			(0.2180)	(0.2188)	(0.2195)
Loc_t				0.1150	0.1143
				(0.2090)	(0.2097)
$Time_t$					-0.0023
					(0.0279)
Vol_t	0.0577*	0.0546*	0.0548*	0.0550*	0.0657*
	(0.1829)	(0.0184)	(0.0184)	(0.0184)	(0.0205)
Log L	-479.56	-478.64	-478.58	-478.42	-474.26
Cases correct	417	418	418	418	405
NOB	706	706	706	706	701

Table 3: *continued* Regression Results - Price Clustering of SNB Interventions

Ending in '5'					
Constant	-1.0367*	-1.0372*	-0.9800*	-0.9849*	-1.2120*
	(0.2644)	(0.2648)	(0.3364)	(0.3372)	(0.5060)
$DomBank_t$	0.7084*	0.7120*	0.7102*	0.7135*	0.7078*
	(0.2442)	(0.2752)	(0.2753)	(0.2757)	(0.2762)
$BigBank_t$		-0.0054	-0.0083	-0.0127	-0.0015
		(0.1876)	(0.1879)	(0.1890)	(0.1898)
$Repeat_t$			-0.0621	-0.0664	-0.0801
			(0.2251)	(0.2260)	(0.2266)
Loc_t				0.0468	0.0458
				(0.2182)	(0.2188)
$Time_t$					0.0242
					(0.0292)
Vol_t	-0.0247	-0.0246	-0.0247	-0.0246	-0.0338
	(0.0179)	(0.0180)	(0.0180)	(0.0180)	(0.0207)
Log L	-449.29	-449.29	-449.26	-449.23	-445.07
Cases correct	463	463	463	463	460
NOB	706	706	706	706	701

Table 3: *continued* Regression Results - Price Clustering of SNB Interventions

Ending in '0' or '5'					
Constant	0.4736	0.5118	0.4692	0.4383	0.1095
	(0.3032)	(0.3034)	(0.4008)	(0.4023)	(0.5832)
$DomBank_t$	0.3334	0.1037	0.1049	0.1211	0.1098
	(0.2423)	(0.2791)	(0.2793)	(0.2799)	(0.2803)
$BigBank_t$		0.3536	0.3558	0.3341	0.3405
		(0.2208)	(0.2212)	(0.2222)	(0.2227)
$Repeat_t$			0.0445	0.0244	0.0124
			(0.2729)	(0.2737)	(0.2740)
Loc_t				0.2642	0.2634
				(0.2751)	(0.2752)
$Time_t$					0.0286
					(0.0286)
Vol_t	0.0738*	0.0682*	0.0684*	0.0693*	0.0662*
	(0.0287)	(0.0287)	(0.0288)	(0.0289)	(0.0292)
Log L	-350.18	-348.92	-348.91	-348.42	-347.63
Cases correct	563	563	563	563	558
NOB	706	706	706	706	701

Notes: The dependent variable is a dummy variable +1 if the end digit is '0', '5' or '0' and '5'; otherwise 0; $DomBank_t$ is a dummy variable that the SNB intervention was transacted with a Swiss commercial bank; $BigBank_t$ is the same as Domestic Bank but is applied to Switzerland's big four banks; $Repeat_t$ is a dummy variable controlling for successive same day interventions; Loc_t is a dummy variable controlling for the location of the counterparty; $Time_t$ is time of transaction; Vol_t is the interventions size in US dollars. Values in parentheses are standard errors.

Table 4: Regressions: Price Clustering of SNB Customer Transactions

Ending in '0'			
Constant	-1.4591*	-1.5939*	-1.5995*
	(0.2166)	(0.2286)	(0.2474)
BIS_t	-0.7867*	-0.7592*	-0.7127*
	(0.2027)	(0.2037)	(0.2112)
$Repeat_t$		0.3884*	0.4076*
		(0.1821)	(0.1870)
$Time_t$			0.0337
			(0.0329)
Vol_t	-0.0186*	-0.0189*	-0.0188*
	(0.0066)	(0.0066)	(0.0072)
Log L	-381.67	-379.41	-360.27
Cases correct	600	600	560
NOB	765	765	718

Table 4: *Continued* Price Clustering of SNB Customer Transactions

Ending in '5'			
Constant	-2.5436*	-2.4689*	-2.5239*
	(0.2166)	(0.2538)	(0.2722)
BIS_t	-1.4964*	-1.5140*	-1.5361*
	(0.2478)	(0.2485)	(0.2597)
$Repeat_t$		-0.2293	-0.2270
		(0.2036)	(0.2102)
$Time_t$			0.0112
			(0.0369)
Vol_t	-0.0021	-0.0023	-0.0100*
	(0.0046)	(0.0046)	(0.0047)
Log L	-332.81	-332.17	-313.44
Cases correct	630	630	590
NOB	765	765	718

Table 4: *Continued* Price Clustering of SNB Customer Transactions

Ending in '0' or '5'			
Constant	-1.0913*	-1.1435*	-1.1983*
	(0.1696)	(0.1791)	(0.1941)
BIS_t	-1.4172*	-1.4075*	-1.3929*
	(0.1711)	(0.1714)	(0.1776)
$Repeat_t$		0.1530	0.1744
		(0.1619)	(0.1671)
$Time_t$			0.03535
			(0.0311)
Vol_t	-0.0122*	-0.0122*	-0.0107*
	(0.0043)	(0.0043)	(0.0045)
Log L	-464.58	-464.13	-438.16
Cases correct	507	507	478
NOB	765	765	718

Notes: Notes: The dependent variable is a dummy variable +1 if the end digit is '0', '5' or '0' and '5'; otherwise 0; BIS_t is a dummy variable if the SNB customer transaction was transacted with the BIS; $Repeat_t$ is a dummy variable controlling for successive same day transactions; $Time_t$ is time of transaction; Vol_t is the interventions size in US dollars. Values in parentheses are standard errors.