Measuring "Herstatt Risk"

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"Herstatt risk" occurs when one party may not be able to receive another party's currency after delivering its own due to the delivery lag between the two currencies traded in the foreign exchange market. This risk can be measured by assuming that it is an increasing function of the delivery lag and transaction value. As a result, the degree of Herstatt risk can be obtained by market, type of transaction, and currency. One way to reduce the risk is to realize "delivery versus payment" between any two currencies.

I. Introduction

Large transactions in today's international securities markets are generally settled by delivery versus payment (DVP), a system which ensures simultaneous delivery and payment. For example, transactions in Eurobonds and other public debt instruments issued in many different countries are settled through the DVP services of private clearing organizations such as Euroclear[1] and CEDEL.[2] In the same way, government bonds in the United Kingdom and the United States are settled through the Central Gilts Office System (CGO)[3] and Fedwire,[4] respectively, both of which provide DVP services. Recently, many private institutions, including the Group of Thirty (G30)[5] and Fédération Internationale des Bourses des Valeurs (FIBV),[6] have come forward in quick succession to recommend the adoption of DVP systems.

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[1]Euroclear, based in Brussels (Belgium), is a delivery versus payment system between funds and securities, run virtually by the Morgan Guarantee Trust Bank.

[2]CEDEL, based in Luxembourg, is a system similar to Euroclear run by European and U.S. banks other than Morgan.

[3]Central Gilts Office System, the central transfer system for gilt-edged securities run by the Bank of England, ensures DVP with payment guarantees from clearing banks.

[4]Fedwire, a delivery versus payment system between U.S. Treasuries and dollar funds, is run by the Federal Reserve System in the United States.

[5]Group of Thirty: a private sector group consisting of about 30 financial experts from around the world which makes recommendations on the international economy and financial system.

[6]Fédération Internationale des Bourses des Valeurs is a private body of major stock exchanges worldwide.

Due to different delivery times for two currencies, reflecting different geographical location, foreign exchange transactions involve the risk of default by one of the parties concerned, which would prevent one party from receiving the agreed amount in currency A after its payment of currency B. However, no DVP plan is in place for any foreign exchange transaction, nor have there been any proposals for introducing any in the near future.

In foreign exchange markets, the risk arising from possible non-delivery versus payment is called "Herstatt risk." This paper attempts to calculate the global scale of such risk and analyze it by market, type of transaction, and currency. Utilizing the central banks' joint triennial surveys of their respective foreign exchange markets, this paper defines and quantifies Herstatt risk as the product of the gap between the settlement time (or "delivery lag") for each currency multiplied by the value of unsettled balances (expressed in "U.S. dollar hours").

Following this introduction, Section II defines Herstatt risk, reviews its background, and considers its significance. Section III introduces a simple framework for discussing calculation of Herstatt risk and uses actual figures as the basis for analyzing it by market, type of transaction, and currency.

The findings can be summarized as follows:

(1) Herstatt risk occurs when one party may not be able to receive the other party's currency after delivering its own due to the delivery lag between two currencies traded in the foreign exchange market.

(2) In a foreign exchange transaction, no matter where effected, final deliveries are always in the respective issuing countries of the traded currencies on the value date stipulated. As a result, an issuing country's distance from the International Date Line — that is, the time difference — assumes special significance in dealing with Herstatt risk.

(3) An assessment of the "big three" markets shows that Herstatt risk is highest in Tokyo, followed by London and New York. This reverses the order of the three exchanges' turnover, with Tokyo's figure at the top instead of in third place. On the other hand, analysis by type of transaction indicates that the highest risk is in yen-dollar transactions, which involve the longest delivery lag and highest turnover, accounting for more than half of the three markets' total. By currency, the risk of failure to receive U.S. dollars, the currency unit issued farthest west of the International Date Line, accounts for 99% of the aggregate risk in the "big three" markets.

II. The Herstatt Risk Concept

A. Definition

In a typical foreign exchange transaction, a buyer and seller exchange two different currencies, with deliveries effected in respective issuing countries on the value date. When there is a time difference, the two currencies are delivered at varying times, giving rise to a delivery lag. After fulfilling its own obligation, the party that is to receive a currency later is exposed to default risk by its counterpart.

This risk, affecting one of the parties due to the delivery lag between two currencies, is called "Herstatt risk" or "Herstatt crisis" (Leigh-Pemberton, 1989) reflecting the panic arising from the bankruptcy of the Herstatt Bank in West Germany. This episode developed as follows (Adachi, 1983).

In June 1974, the Herstatt Bank, a West German commercial bank, failed because of speculative foreign exchange dealing. With its operations devastated by the collapse, the bank was declared bankrupt on the afternoon of June 26 under a business suspension order issued by the regulatory authority. Many banks had foreign exchange contracts with the Herstatt Bank for settlement on that date. These banks, and others which had bought U.S. dollars for European currencies, including the German mark, found themselves in serious trouble. They had delivered their European currency obligations during the morning hours (German standard time), but could not receive U.S. dollar funds in New York because the Herstatt Bank's operations were suspended shortly after. Like ordinary deposit creditors, some of these banks were able to recover their losses gradually as bankruptcy proceedings progressed, but many ended up with losses in varying amounts. As a result, time lags in currency settlement and also unsettled currency balances were widely recognized as a real and present "risk."[7]

B. Calculation method

Risk is often expressed as "loss probability times loss amount." This paper adopts this formula in calculating Herstatt risk. To begin with, under the circumstances where Herstatt risk emerges as a problem, it is apparent that the amount of loss sustainable by a party to a transaction equals the unsettled amount of that transaction (original value of the contract); loss probability is the degree of probability of default by the counterparty, which is thought to be an increasing function of the time delay from the delivery of a currency by a party to its receipt of another currency (delivery lag between the two currencies). There is a certain probability of default, however small, in financial transactions due to operational error and unsuccessful speculation. The longer the delivery lag, the higher the probability of default. This is the same as the situation where, when a card is drawn from a deck, the probability of drawing the ace of spades increases with the number of draws. Since the foreign exchange market is open around the clock and computers normally operate on a 24-hour basis, there seems little doubt that virtually all financial institutions have the possibility of defaulting in their financial transactions around the clock. It is thought justifiable, therefore, to simplify this situation and assume that the probability of default by the counterparty increases in proportion to the length of delivery lag (time delay).[8] Also,

[7]The shift of CHIPS from overnight settlement to same-day settlement is attributed to this incident.

for simplification, differences in the credibility of each party to the transaction are ignored and assumed to be the same (see Appendix I for other simplifications in calculating Herstatt risk).

Under these assumptions, Herstatt risk can be expressed as a product of delivery lag times transaction amount:

Herstatt risk	=	Value of transaction	×	Delivery lag
(US$ hours)		(US$)		(hours)

Take, for example, a foreign exchange contract concluded between banks A and B for US$1 million, where A sells yen to buy US dollars. The yen obligation is delivered at 15:00 (Japan standard time) on the value date in Japan through the Gaitame-Yen System, while the U.S. dollar obligation is delivered at 18:00 (Eastern standard time) on the value date in the United States through CHIPS. There is, then, a lag of 17 hours: the three-hour difference in operations (18:00 in New York and 15:00 in Tokyo) in addition to the geographical time difference of 14 hours between Japan standard time and Eastern standard time in the United States, with the yen obligation being delivered before delivery of the U.S. dollar obligation. Herstatt risk in this example is calculated as follows:

US$1 million × 17 hours = 17 million US$ hours.

In this transaction, Bank A — the buyer of dollars — is exposed to Herstatt risk since the dollar obligation is delivered after the yen.

This definition of Herstatt risk holds the advantage of being able to simplify discussion. There is a specified delivery time for every currency as long as the supposition that "a currency is ultimately settled in its country of issue" remains valid. The delivery lag

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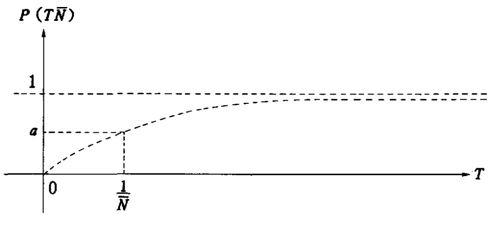
[8]In a strict definition, the following relationship exists between time lag and default probability. When the probability of default per transaction by a party is expressed as $a(0<a<1)$, the probability of one or more defaults during n transactions expressed as $P(n)$ can be calculated as follows:

$$P(n) = 1-(1-a)^n$$

Assuming that the party is engaged in $\bar{N}$ transactions per hour, the number of transactions reaches $T\bar{N}$ times in T hours and the probability of default per hour becomes

$$P(T\bar{N}) = 1-(1-a)^{T\bar{N}}$$

This equation can be transformed into the diagram below, with the probability of default gradually approaching 1 with the passage of time (as $T\rightarrow\infty$, $P(T\bar{N})\rightarrow 1$).



for a certain pair of currencies can, therefore, be determined according to one given rule. Since currencies traded by banks are usually delivered through their correspondent banks or overseas branches, the fact that delivery lag between two currencies is given is true of any transaction, regardless of where or who entered into the contract for the two currencies.

Take yen-dollar transactions between British banks in the London foreign exchange market, for example. Yen is always settled through the Gaitame-Yen System in Tokyo, while U.S. dollars are settled via CHIPS in New York. Also, in this case, the delivery lag for the yen obligation is equal to the time delay (17 hours) between the final settlement time in the Gaitame-Yen System and CHIPS. Herstatt risk in any yen-dollar transaction can be measured by multiplying this delivery lag by the value of the transaction. The same applies to other combinations of currencies such as the mark-dollar and mark-yen.

III. Calculating Herstatt Risk

This chapter describes the framework for the discussion that follows and the nature of Herstatt risk.

A. Discussion framework

1. Scenario

First, consider the Tokyo, London, and New York foreign exchange markets and the five currencies — the Japanese yen, the German mark, the Swiss franc, the British pound, and the U.S. dollar — that are traded in and between them. Since a typical transaction involves the exchange of two currencies, the utilization of five currencies leads to ten combinations:[9,10]

(1) yen-mark
(2) yen-Sw. franc
(3) yen-pound
(4) yen-dollar
(5) mark-Sw. franc
(6) mark-pound
(7) mark-dollar
(8) Sw. franc-pound
(9) Sw. franc-dollar
(10) pound-dollar

A total of 30 combinations is possible theoretically since transactions involving these ten combinations can be effected in each of the three markets mentioned.

2. Value of transactions

Table 1 shows results of joint turnover surveys conducted in respective foreign exchange markets in April 1989 by the Bank of Japan (BOJ), the Bank of England (BOE), and the Federal Reserve Bank of New York (the Fed) (see Appendix II for technical

[9]A transaction that does not involve dollars is called a "cross transaction."

[10]Hereafter, currencies and markets will be ordered according to their proximity to the International Date Line.

Table 1. Average Daily Turnover in Major Foreign Exchange Markets (April 1989)

(US$ million)

	Tokyo	London[a]	New York[b]	Total	(%)
Yen/mark	1,075	0	960	2,035	0.6
Yen/Sw. franc	774	0	0	774	0.2
Yen/pound	420	0	0	420	0.1
Yen/dollar	80,066	28,050	33,826	141,942	39.6
Mark/Sw. franc	0	0	1,393	1,393	0.4
Mark/pound	0	5,610	659	6,269	1.7
Mark/dollar	10,815	41,140	41,599	93,554	26.1
Sw. franc/pound	0	0	0	0	0.0
Sw. franc/dollar	4,783	18,700	15,265	38,748	10.8
Pound/dollar	4,731	50,490	18,231	73,452	20.5
Dollar transactions	100,395	138,380	108,921	347,696	97.0
Cross transactions	2,269	5,610	3,012	10,891	3.0
Total	102,664	143,990	111,933	358,587	100.0
(%)	28.6	40.2	31.2	100.0	

[a] The value of each combination is estimated by calculating its share of total adjusted turnover.
[b] Cross transaction turnover is estimated by calculating each combination's share of total adjusted turnover.

aspects of compilation).

Since transaction value is one of the two factors constituting Herstatt risk, it calls for some simple fact-finding based on Table 1.

First, the combined daily turnover of the three markets is \$359 billion, with dollar transactions accounting for an overwhelming 97.0% and the remainder made up of cross transactions.

Second, by type of transaction, the yen-dollar is the most common combination at \$142 billion (39.6%), followed by the mark-dollar at \$94 billion (26.1%), and the pound-dollar at \$73 billion (20.5%).

Third, by market, London is the largest followed by New York and Tokyo, with \$144 billion (40.2%), \$112 billion (31.2%), and \$103 billion (28.6%), respectively.

Fourth, by ratio of cross transactions, London's 3.9% shows the most diversified foreign exchange transactions, followed by New York's 2.7% and Tokyo's 2.2%.

Fifth, the shares of the most heavily-traded combinations in these markets are 35.1% for the pound-dollar in London, 37.2% for the mark-dollar in New York, and 78.0% for the yen-dollar in Tokyo.

3. *Delivery lag*

Before we turn to examine delivery lag — the second factor in Herstatt risk — we must first examine the payment systems for the delivery of each currency (see Figure 1 and Table 2).

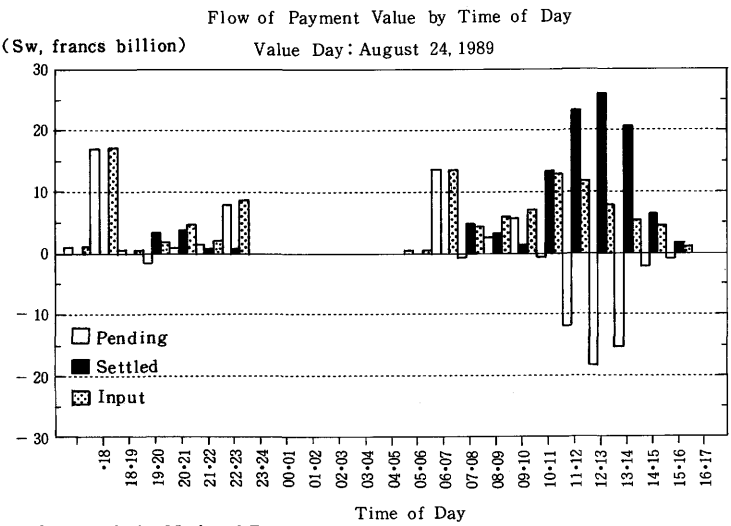
The payment systems in place for each currency are: the Gaitame-Yen System for Japanese yen, a clearing system offered by the Bundesbank in West Germany for the German mark, Swiss Interbank Clearing (SIC) for the Swiss franc, CHAPS for the pound sterling, and CHIPS for the U.S. dollar.[11]

With the exception of SIC and CHIPS, the final settlement time for these systems is 15:00, the central banks' business closing hour.[12] Settlement through CHIPS ends at 18:00 via Fedwire. SIC, which settles transactions on a 24-hour real-time basis, has no fixed settlement hours. For simplicity of this discussion, however, 12:00 is considered as SIC's final settlement time, since settlement value peaks at that time.[13]

[11]However, currencies traded in foreign exchange markets are not always settled through these systems. Let us take the delivery of yen in yen-dollar transactions, for example. Almost all transactions outside the Tokyo market ("out-out" transactions) and those between domestic banks and offshore banks ("in-out" transactions) use the Gaitame-Yen System. In contrast, transactions between domestic units ("in-in" transactions), which account for approximately 60% of turnover in the Tokyo market, are settled through the check-clearing system, a next-day settlement system in Japan. They are cleared one day before value date so that they are actually paid on the value date. The check-clearing system settles its balance at 13:00, two hours earlier than the final settlement of 15:00 in the Gaitame-Yen System. On the other hand, approximately 1% of dollar transactions are settled through Fedwire (FRB NY, 1988). In this case, as well, final settlement time is earlier than for settlements through CHIPS. The discussion here, however, ignores all these factors and assumes that settlements are made through the systems mentioned above.

[12]Yen-dollar transactions between Japanese banks in the Tokyo market are settled early in the evening through the Tokyo Dollar Clearing System, run by the Tokyo branch of the Chase Manhattan Bank. This is an interim step, however. Participants' positions are transferred to New York and finally settled through CHIPS the next day. Even with the Tokyo Dollar Clearing System, then, the final settlement time for dollar obligations is that of CHIPS (18:00 Eastern standard time in the United States). In this sense, offshore settlement systems like the Tokyo Dollar Clearing System do not essentially affect the discussion in this paper.

[13]The value of transactions settled through the SIC is as shown below.



Source: Swiss National Bank.

Figure 1. Delivery Lags

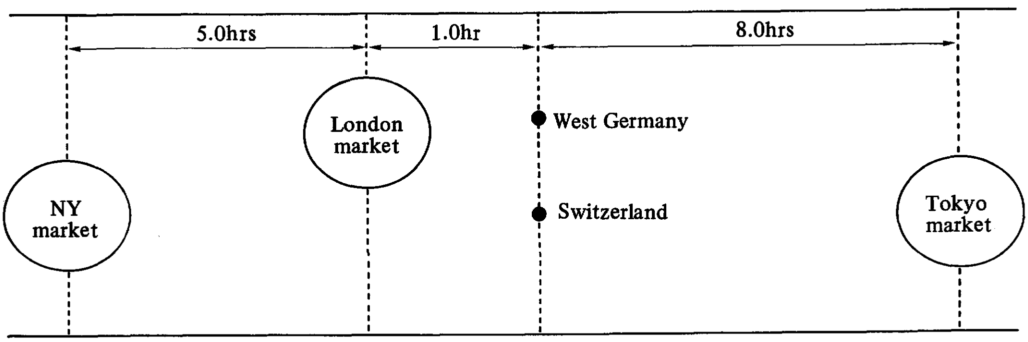


Table 2. Delivery Lags

Currency	Payment system	Local settlement time	Time difference between countries[a]	Delivery lag[b]
			(hours)	
Yen	Gaitame-Yen System	15:00		
			8.0	8.0
Mark	Clearing system of the Bundes-bank	15:00		
			0.0	-3.0
Sw. franc	SIC	12:00		
			1.0	4.0
Pound	CHAPS	15:00		
			5.0	8.0
Dollar	CHIPS	18:00		

[a] Standard time.

[b] A general formula for the degree of delay in the delivery of currency B (the currency issued by country B which is farther from the International Date Line) after the delivery of currency A (the currency of country A located closer to the International Date Line) is as follows:

$$\text{Time difference between country A and country B} + \left\{ \text{Local time of final settlement for currency B} - \text{Local time of final settlement for currency A} \right\} \text{(hours)}$$

When this figure has a minus, currency B is delivered before currency A. This example shows that the Sw. franc is delivered three hours earliei than the mark. Note, however, that these figures have absolute values since negative figures have no significance in calculating Herstatt risk.

One factor in calculating the delivery lag between each currency is the time difference between the countries of the payment systems handling each currency. The time differences are eight hours between Japan and West Germany, none between West Germany and Switzerland, one hour between Switzerland and the United Kingdom, and five hours between the United Kingdom and the United States (Eastern standard time). As shown in Table 3, the delivery lag for each pair of currencies can be obtained by adding the difference in each payment system's local time for final settlement to this geographical time difference in standard time.[14]

The yen-dollar delivery lag of 17 hours is by far the longest.

B. Magnitude of Herstatt risk

As noted before, the delivery lags calculated in the preceding paragraph are inherent in the type of transaction and are unaffected by the market where they occur. Therefore, the size of Herstatt risk can be calculated by multiplying each transaction value by the delivery lag. Table 4 shows the magnitude of Herstatt risk and Tables 5 and 6 give a breakdown within each market and by transaction category.

Based on these tables, the magnitude of Herstatt risk can be described as follows:

By market, combined average daily Herstatt risk in the three markets in April 1989 was US$4,342 billion hours.[15] Tokyo had the highest risk with US$1,570 billion hours (36.2% of the three-market total), the reverse of its bottom ranking in terms of simple turnover, followed by London with US$1,481 billion hours (34.1%), and New York with US$1,291 billion hours (29.7%). This is because the Tokyo market has the highest turnover of yen-dollar transactions, which have the longest delivery lag of all currency combinations.

By currency pair, at US$2,413 billion hours (55.6% of all transactions) the yen-dollar combination stands out as being the largest by far. This is followed by the mark-dollar at US$842 billion hours (19.4%), the pound-dollar at US$588 billion hours (13.5%), and the Sw. franc-dollar at US$465 billion hours (10.7%), with the dollar included in all of these combinations. Other pairs are minuscule with a combined risk share of 0.8%. The substantial Herstatt risk associated with the yen-dollar combination reflects it having the

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[14]In this discussion, delivery lags are calculated according to the current international practice of value-date payment, requiring that each currency be settled on a certain value-date. By the nature of these transactions, however, the parties should be able to agree on whichever mode of settlement they prefer. In a yen-dollar transaction, for example, they can arrange for New York delivery of a dollar obligation on a specified date and a Tokyo delivery of a yen obligation on the "next day." In this case, the delivery lag is only seven hours (New York-Tokyo), instead of the usual 17 hours (Tokyo-New York).

[15]In foreign exchange markets, spot transactions are always settled on the second day following trading, while obligations in forward transactions are delivered at a later date. More precisely, then, this situation can be described as "on average, potential Herstatt risk is generated daily in the magnitude of US$4,342 billion hours." Since this is, in fact, an ongoing process, this situation can be considered as the "average daily magnitude of Herstatt risk." The following discussion is premised on this observation without referring to specific examples.

Table 3. Delivery Lags by Transaction Type

	Hours
Yen/mark	8
Yen/Sw. franc	5
Yen/pound	9
Yen/dollar	17
Mark/Sw. franc	3
Mark/pound	1
Mark/dollar	9
Sw. franc/pound	4
Sw. franc/dollar	12
Pound/dollar	8

Table 4. Magnitude of Average Daily Herstatt Risk

(US$ hours, million)

	Tokyo	London	New York	Total	(%)
Yen/mark	8,600	0	7,680	16,280	0.4
Yen/Sw. franc	3,870	0	0	3,870	0.1
Yen/pound	3,780	0	0	3,780	0.1
Yen/dollar	1,361,122	476,850	575,042	2,413,014	55.6
Mark/Sw. franc	0	0	4,179	4,179	0.1
Mark/pound	0	5,610	659	6,269	0.1
Mark/dollar	97,335	370,260	374,391	841,986	19.4
Sw. franc/pound	0	0	0	0	0.0
Sw. franc/dollar	57,396	224,400	183,180	464,976	10.7
Pound/dollar	37,848	403,920	145,848	587,616	13.5
Dollar transactions	1,553,701	1,475,430	1,278,461	4,307,592	99.2
Cross transactions	16,250	5,610	12,518	34,378	0.8
Total	1,569,951	1,481,040	1,290,979	4,341,970	100.0
(%)	36.2	34.1	29.7	100.0	

Table 5. Risk Burden Ratio by Market* (%)

	Tokyo	London	New York
Yen/mark	0.5	0.0	0.6
Yen/Sw. franc	0.2	0.0	0.0
Yen/pound	0.2	0.0	0.0
Yen/dollar	86.7	32.2	44.5
Mark/Sw. franc	0.0	0.0	0.3
Mark/pound	0.0	0.4	0.1
Mark/dollar	6.2	25.0	29.0
Sw. franc/pound	0.0	0.0	0.0
Sw. franc/dollar	3.7	15.2	14.2
Pound/dollar	2.4	27.3	11.3
Dollar transactions	99.0	99.6	99.0
Cross transactions	1.0	0.4	1.0
Total	100.0	100.0	100.0

* Herstatt risk for certain transactions in each market against a base of 100 representing total Herstatt risk for each market.

Table 6. Risk Burden Ratios by Transaction Type* (%)

	Tokyo	London	New York	Total
Yen/mark	52.8	0.0	47.2	100.0
Yen/Sw. franc	100.0	0.0	0.0	100.0
Yen/pound	100.0	0.0	0.0	100.0
Yen/dollar	56.4	19.8	23.8	100.0
Mark/Sw. franc	0.0	0.0	100.0	100.0
Mark/pound	0.0	89.5	10.5	100.0
Mark/dollar	11.6	44.0	44.5	100.0
Sw. franc/pound	0.0	0.0	0.0	0.0
Sw. franc/dollar	12.3	48.3	39.4	100.0
Pound/dollar	6.4	68.7	24.8	100.0

* Herstatt risk for certain transactions in each market against a base of 100 representing the total for each type of transaction.

longest delivery lag (17 hours) as well as largest transaction value (US$142 billion). It should be noted that more than half (56.4%) of Herstatt risk in the yen-dollar combination is in Tokyo, where turnover in this category is the highest in the world (see Table 6).

Herstatt risk by type of transaction can be broken down by currency, which refers to the risk if a certain currency becomes unobtainable. In transactions involving the dollar — such as yen-dollar, mark-dollar, Sw. franc-dollar, and pound-dollar — only the dollar can be defaulted since dollar obligations are always delivered after other currencies. These transactions are therefore categorized under dollar Herstatt risk. Likewise, the risk in yen-pound, mark-pound, and Sw. franc-pound combinations is classified under pound Herstatt risk, while the risk in yen-Sw. franc transactions is grouped under Swiss franc Herstatt risk. Finally, the risks involved in yen-mark and mark-Sw. franc combinations fall under German mark Herstatt risk.[16] Since the yen is delivered earliest in all these combinations, yen Herstatt risk is, in effect, non-existent.

Table 4 shows that dollar Herstatt risk at 99.2% dominates the world total. This implies that, virtually without exception, the dollar is the currency of default when Herstatt risk occurs. In this sense, the dollar is a "risky currency" compared with the others, while there is practically no possibility of a yen default, even if Herstatt risk can be posited theoretically.

In general, Herstatt risk by currency increases the farther an issuing country is from the International Date Line; conversely, it is lower the closer a country is to the International Date Line. In this sense, there is inconsistency among these countries' currencies in terms of Herstatt risk.

IV. Concluding Remarks

The preceding sections have described Herstatt risk. One measure to reduce Herstatt risk is to realize delivery versus payment between two different currencies.[17] Generally speaking, in order to deliver a currency from one bank to another, funds must be transferred between accounts with the central banks of issue. Therefore, developing a delivery versus payment system for two different currencies requires close cooperation between the central banks concerned.

To reduce Herstatt risk, the first requirement is to recognize the necessity of cooperation between central banks and to choose appropriate methods. One criterion in this regard is whether the common interest of the global market or the interest of the national market should be the higher priority.

In addition to Herstatt risk discussed in this paper, there is also a risk stemming from

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[16]Mark-Sw. franc transactions are classified under mark Herstatt risk because, in this paper, the Swiss franc is assumed to be delivered at noon (before the German mark) in the same time zone.

[17]While the introduction of netting by novation can also reduce Herstatt risk by shrinking settlement amounts, it cannot eliminate the risk completely.

the time lag between transaction and settlement. Although this risk, tentatively called the "transaction-settlement lag risk" may be analyzed according to the issues developed here, it has been left for another study.

Herstatt risk and transaction-settlement lag risk share a common feature, i.e. the disequilibrium of floating currencies due to the settlement lag. Because of this, these risks are sometimes grouped together and called an "international float." As foreign exchange transactions have experienced enormous expansion in recent years, it is necessary to recognize this international float as a form of risk and to analyze it from various perspectives.

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Appendix I. Simplification of Concepts and Applications of Herstatt Risk

In considering Herstatt risk, this paper has simplified certain factors to prevent discussion from becoming unnecessarily complex.

First, in referring to a currency's delivery time, this paper does not take into account the time at which a transaction becomes irrevocable (final). This paper assumes that delivery coincides with when the payment system concerned closes. If payment instructions before that time are irrevocable as soon as they are issued (either operationally or legally), it has the same effect as delivery. Such a situation heightens Herstatt risk since it extends the delivery lag by the same margin (frame ② in Figure A-1).

If we consider irrevocable time more explicitly, Herstatt risk includes not only party A receiving a "currency to be delivered at a later time" but also counterparty B "receiving the other currency to be delivered at an earlier time." In this connection, let us look at the case of Delbrueck Bank, which suffered a loss when the Herstatt Bank was ordered to suspend operations and subsequently declared bankrupt.

Herstatt Bank, a commercial bank in West Germany, and Delbrueck Bank, a limited company in the same country, concluded a mark-dollar contract, with Delbrueck buying marks against dollars for settlement on June 26, 1974. On the settlement date, Herstatt Bank was suspended by the regulatory authority. Claiming that the dollar payment instruction was revocable, Delbrueck sued its New York correspondent bank, Manufacturers Hanover Trust, for damages, but lost the case.

This transaction involved marks and dollars, with the dollars to be delivered at a later time. Nonetheless, it was marks which could not be collected, while Delbrueck had paid in dollars, despite the later delivery (see Figure A-2). Theoretically speaking, since the bankruptcy was on the part of the Herstatt Bank, which was obligated to pay marks for earlier delivery, Delbrueck could simply have stopped the scheduled dollar payment and avoided any risk[A-1] since it was obligated to deliver

[A-1]Such stoppage of payment requires prompt transmission of the news of bankruptcy. This paper does not include the "transmission lag in receiving news of bankruptcy factor."

Figure A-1. Extension of Delivery Lag
(Risk of dollar buying in a yen-dollar transaction)

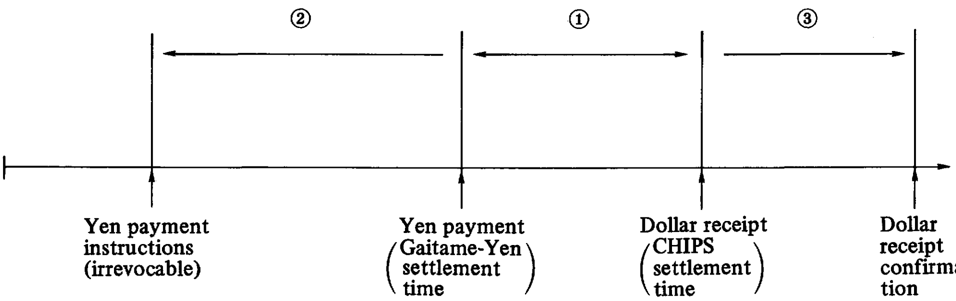
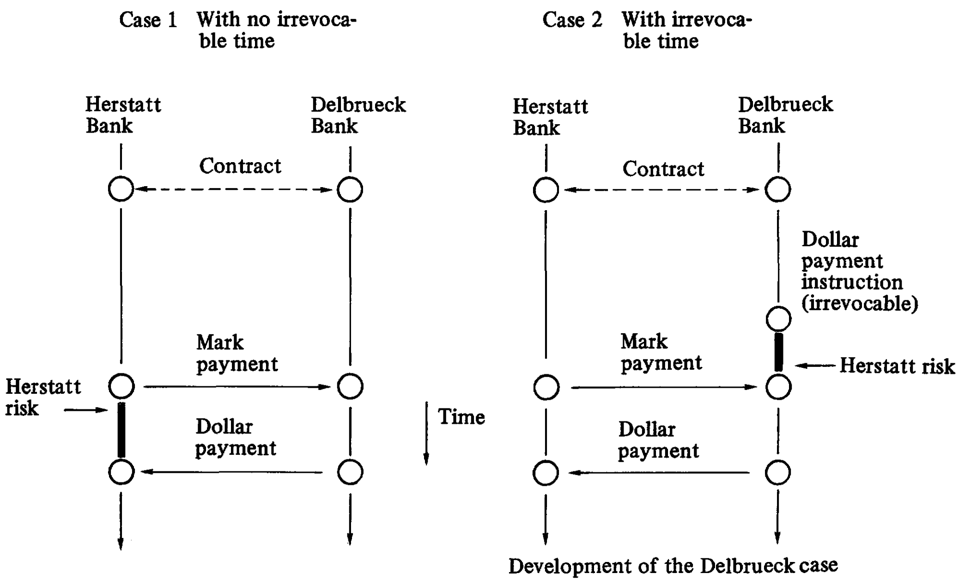


Figure A-2. Analysis of Irrevocable Time



dollars at a later time. As noted above, however, Delbrueck had fulfilled its dollar obligation before the suspension. The bank had issued its dollar payment instructions much earlier than CHIPS's settlement time, which had the same effect as actually paying dollars at that time since the instructions were considered irrevocable. In effect, dollar payment preceded delivery of the marks.

When one of the participants in an international payment system becomes bankrupt and lawsuits are filed for damages, the understanding of final or irrevocable payment instructions could become an issue, as in the Delbrueck case. The problem is that irrevocable time varies according to the laws of each country, the procedures of various payment systems, and established market practices. Since any attempt to incorporate them into the analytical process would seriously complicate the discussion, this paper assumes that a currency's delivery time is when its settlement system closes, disregarding the question of effective irrevocable time. As such, the situation can be simplified to imply that Herstatt risk is always incurred by the party receiving the currency that is delivered later and that such risk materializes upon the bankruptcy of the counterparty — the one obligated to pay a currency to be delivered later.

The second simplification is the disregard of the confirmable time of the receipt of a currency. When a currency has been received through a payment system (such as crediting the receiving bank's account at a foreign correspondent bank), if the fact cannot be confirmed by the recipient until later due to the time difference or other factors, the risk remains for the receiving party, at least subjectively. The risk can, therefore, be interpreted as being correspondingly higher (frame ③ of Figure A-1). Again however, this paper deals only with objective risk and disregards subjective risk inherent in the confirmation process.

The third simplification is the omission of an explicit attempt to determine if the obligations to deliver the two currencies are mutually dependent. In other words, even if there is no delivery lag in a transaction with two currencies, a payment risk remains if deliveries are not both dependent on simultaneous execution by the other party. Conversely, even if there is a delivery lag between two currencies, payment risk is zero when each delivery is conditional on the other (or guaranteed by a third party, as with the Central Gilts Office System in the United Kingdom). In this respect, this paper assumes mutual conditionality between the deliveries of two currencies only when there is no delivery lag. Since the possibility of mutual conditionality or guarantees by a third party are disregarded, the assumption is that the larger the delivery lag, the greater is Herstatt risk.

Appendix II. Technical Problems in Calculating Foreign Exchange Market Turnover

In this paper, "foreign exchange turnover by market" includes separate statistics for three sets of counterparties in transactions: (1) resident/resident, (2) resident/non-resident, and (3) non-resident/non-resident (through resident brokers). Although category (1) doubtless constitutes turnover in a certain market, the interpretation is not so clear for categories (2) and (3). In category (2), for example, when there is a cross-border direct dealing between a Japanese bank in Tokyo and a British bank in London, the results are double counted if the transaction is included in market turnover for both Tokyo and London. Adjustment requires information on the weight of transactions among participants in Tokyo, London, and New York, which are the focus of this paper, including the aggregate of category (2) transactions (or the weight of transactions with participants from countries other than the three). But the joint surveys of these three foreign exchange markets do not necessarily provide sufficient information on this point. Therefore, this paper adds total category (2) figures to the turnover of these markets without any modification. Regarding category (3) transactions, involving brokers as the only residents, there is some doubt as to whether they constitute legitimate turnover in respective markets. Given the extremely small weight they occupy in these markets (0.03% of total in Tokyo), however, figures from the joint surveys are included in each market's turnover as they stand.

Resident/resident transactions in category (1) include interbank transactions and those between banks and their customers. Since bank-customer transactions involving currency delivery obligations are settled through accounts held by customers at their banks, delivery procedures clearly differ from those described in this paper and should, therefore, be excluded from the base for calculating Herstatt risk. Because bank-customer figures are not available in the cross-transaction surveys of the Bank of England and the Fed, however, such adjustment is not attempted in this paper.

Since simply adding transactions between reporting banks results in double-counting, this paper uses figures only after adjustment has been made for double-counting in category (1) transactions.

By type of transaction, "turnover" is a simple aggregate of contracts for (i) outright (spot and forward) transactions and (ii) swap transactions. Since this paper deals with the risk arising from the delivery process, the amount should be doubled for swap transactions involving two (or shuttle) delivery procedures. This was not done, because the volume of swaps in cross transactions is not available for the New York market and swaps are not identified by transaction type in the London market.

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