URHO LEMPINEN — REIJA LILJA

Payment Systems and the Central Bank

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INTRODUCTION AND SUMMARY

1 The Background and Objectives of the Study

The purpose of payment systems is to facilitate economic transactions
and thereby to enhance the efficient utilization of resources in the
economy. The existence of a payment system makes it possible for
wealth valued in terms of units of account accepted by all parties to
be transferred between economic agents. This increases social welfare
in basically two ways. First, by utilizing the opportunities provided
by the payment system to transfer commensurable wealth, economic agents
are able to exchange goods and services between each other anonymously
in the marketplace. Indirect exchange is far more efficient than the
alternative of barter, in which there is a direct exchange of goods
between economic agents. Secondly, the monetary system creates an
alternative way in the economy of transferring wealth over time. This
enhances the intertemporal efficiency of the economy by increasing
agents' opportunites to time their consumption and savings decisions
in an optimal way.

Viewed as a whole, the payment system is a complicated and complex
institution of society, which changes along with technological and
social progress. Both the standards for measuring values employed in
different payment systems and the methods of transferring wealth have
varied greatly at different times. The organization of payment systems
has also varied considerably. Particularly the role and participation
of the public sector in the payment system have varied both in
different periods and societies.

One of the main reasons for undertaking this study is the observation
that developments in the payment system are gradually reducing the role
of the central bank therein. Previously, payments were predominantly
or entirely effected by transferring means of payment. Means of payment
comprised units of partly or totally unbacked money or other means of
payment defined on the basis thereof. The supply of base money and
thus the whole system were under the control of the central bank.

In recent decades, payments have, to an increasing extent, been effected as various kinds of transfers between accounts. Here, too, the values of payments are defined in terms of the central bank's base money, although this does not necessarily have to be the case. In practice, payments are effected only by the private sector (the banking system). In the future, a situation could, in theory, arise in which all payments are effected in the form of transfers between accounts. and in which the values of transfers are measured, for example, in terms of a commodity basket. In such circumstances, the payment system would be fully privatized, and the central bank would not have any role therein.

On the other hand, the gradual replacement of money by transfers between accounts implies the substitution of "money" created internally by the banking system for base money, which is outside the banking system and controlled by the central bank. The combined total of "money" created by the banking system and base money is thought to have a more or less fixed relationship with the level of economic activity. The replacement of base money by "money" created by the banking system might then mean a weakening in the relationship between base money and economic activity. This, in turn, could lead to a diminution in the effects of monetary policy based on the regulation of the supply of base money.

The aims of this study are

(i)   to describe and analyze developments in the Finnish payment system and the present state of the system;

(ii)   to carry out a theoretical examination of the demand for money and payment instruments in general using a number of models and an empirical analysis of the demand for cash and coin) based on Finnish data;

(iii)   to investigate whether the central bank should retain its central role in the evolving accounting system of exchange or whether it would be Pareto optimal for the economy to let the system develop in the market free of any regulation;

(iv)   to examine what kinds of effects the development of the
        payment system will have on the scope for monetary policy to
        influence the economy.

2 The Contents and Results of the Study

The study consists of four essays, which are indirectly linked with
each other. In writing the essays, the aim has been that each of them
could be read as an independent entity. Each essay covers one of the
four research issues set as the objectives of the study. With the
exception of the first one, the essays are fairly technical and
primarily intended for researchers in monetary economics.

The first essay provides a survey of payment systems. The survey
starts with a description which highlights the fact that the primary
purpose of a payment system is to enhance the utilization of resources
in the economy. On the one hand, this occurs because a payment system
makes barter between economic agents unnecessary. Agents need not seek
out persons with matching requirements for the exchange of commodities.
They are able to buy and sell commodities anonymously in the
market-place utilizing the wealth transfer services provided by the
payment system. On the other hand, the allocation of the economy's
resources is enhanced by the fact that money or means of payment in
general create a mechanism in the economy through which wealth can be
transferred over time.

Three basic types of payment systems are then described. It is typical
of monetary systems of exchange that money circulates in the economy
as a means of payment and that all values and prices are measured in
money. Monetary systems are based on the use of either commodity money
or fiat money as the basic unit of the system. In a system of commodity
money, the price of money is determined in terms of either a commodity
basket or some individual commodity. The value of money is secured by
creating stocks of the commodity or commodities or a commodity basket
serving as the standard for the measurement of value and by allowing
full convertibility between money and the standard specie. In a system

of fiat money, the value of money is not based on any real assets. Rather, it is determined in the market purely on the basis of the confidence of economic agents, the amount of money in circulation and the overall state of the economy. In an accounting system of exchange, wealth is transferred by means of transfers between accounts, and, under a pure system, there are no means of payment circulating in the economy. The values of transfers between accounts can be measured according to any standard whatsoever.

As regards basic types of payment systems, it can be briefly noted (a thorough analysis of this issue is presented in the third essay) that a system of fiat money entails a fundamental risk of instability. The risk is due to the fact that the market price of fiat money is many times - even many hundred times - greater than its cost of manufacture. Because of this risk of instability it is generally considered necessary for the supply of fiat money to be fully controlled by the government. The system of commodity money and the accounting system of exchange are not thought to involve a similar risk of instability, and accordingly they can be operated by the private sector.

Next, the Finnish payment system is briefly examined. It is pointed out that this system is a mixed system in which the measurement of values is based on fiat money. Moreover, notes and coin are used to a great extent for payments. On the other hand, in the Finnish system many payments are effected through giro transfers. Compared internationally, the system has developed a long way towards an accounting system of exchange and it provides a fairly wide range of services to its users.

Finally, the cost structure of the various payment methods in the payment system is examined and some rough estimates of the cost of the entire payment system in Finland are given. The total cost of the system is estimated to amount to FIM 4 - 12 billion annually at 1987 prices, so that the transfers of wealth necessitated by economic activity consume about 1 to 3 per cent of GDP.

In the second essay, the demand for means of payment is analyzed. The essay begins with a brief review of the foundations of monetary theory.

At the core of monetary theory lies the quantity theory, according to which real demand for money depends on the volume of transactions and the velocity of money. A rise in the level of nominal interest rates increases the velocity of money while a fall decreases it.

The underlying principle of the quantity theory is that fiat money is either the only or a relatively efficient means of payment. However, this cannot be regarded as a fully justified point of departure for constructing a model of demand behaviour in a modern payment system. The prevailing payment system is characterized by the fact that all or almost all forms of wealth can be used for payment in certain situations, without converting them into money. Accordingly, the construction of a model of the demand for means of payment should be based on the notion that means of payment are forms of wealth which are "inexpensive" or "easy" to use for payment. The demand for means of payment is examined in a number of partial models on this basis. In these models, the demand for a particular means of payment depends on such factors as its yield and risks, the transactions costs and security risks attached to it, its suitability in different payment situations, qualitative aspects related to payment (whether, for example, the means of payment can be used anonymously) and the corresponding properties of alternative forms of wealth.

Finally, the demand for cash (notes and coin) in Finland is considered. It is argued that the demand for various denominations may respond differently to changes in real income, interest rates or the inflation rate, and that improvements in transactions technology may have a significant impact on the demand for different means of payment. In the analysis, tentative evidence is put forward to show that technical progress has reduced the transactions costs of other payment instruments relative to currency since the mid 1970s, thus having a negative impact on the relative demand for different denominations during this period. In model specifications in which technical progress is not accounted for, this phenomenon shows up as very low, or even negative, income elasticities.

The third essay deals with the problem of whether the central bank should participate - and if so, on what grounds - in the payment

system either as an executive body or as a supervisory and regulatory authority. The problem is examined from the point of view of the underlying stability and efficiency of the payment system.

This essay first examines the question of the stability of the payment system. It is noted that, under the system of fiat money, the risk of instability (the risk of very rapid inflation) seems to be smaller when the central bank controls the supply of money and money is not a private institution. This is due to the fact that the large issue profits relating to the institution of fiat money create a permanent economic incentive in the system for private producers of money to issue an excessive amount of money. Admittedly, this risk also exists for the same reason when the central bank controls the supply of money. The analysis further shows that the extreme form of instability - the risk of hyperinflation - is eliminated if only part of the money supply is backed by real assets. The higher the fraction which is backed the smaller will be the risk of an acceleration of inflation. Consequently, it is clear that commodity money systems in which money is fully backed do not entail this risk, irrespective of whether the private or the public sector produces the money used in the economy. A pure accounting system of exchange may also be interpreted as a kind of commodity money system with full backing, so that it, too, can be operated as a private service without any risk of instability.

According to the analysis in this essay, the efficiency of the payment system depends, on the one hand, on whether the system is centralized or decentralized. On the other hand, it depends on whether the system is operated entirely by the private sector or partly or totally controlled or operated by the public sector.

The centralization of the payment system gives rise to savings in economic costs whenever the provision of payment system services involves economies of scale. Particularly electronic payment systems making extensive use of information technology involve substantial fixed costs. It can therefore be presumed that their operation entails economies of scale, which could be exploited by centralizing systems.

It is worth nationalizing a centralized payment system, if there is no effective threat of entry to the market for payment services which might force a private company operating the centralized system to act efficiently from the macroeconomic point of view. Global economies of scale, together with the absence of threat of entry, would constitute the case of natural monopoly in the market. The potential benefits to be had from the nationalization of the payment system are reduced or totally eliminated, if there are strong economies of scope between the provision of payment services and financial intermediation. In that case, the public sector is not able to provide payment services in the most efficient way, unless it engages in financial intermediation itself. The benefits deriving from the economies of scope may, however, be ostensible and based mainly on the utilization of transit items ('float').

Finally, it is noted that it may be necessary for the central bank to control the functioning and development of the payment system through various guidelines, norms, economic incentives and possibly through its own investments. This is favourable for the economy as a whole, because a number of externalities are associated with the functioning of the payment system.

One externality arises from the fact that the prices of payment services are generally below market prices. Thus payment services are, as a whole, subsidized services, which implies an inefficient use of resources. From the macroeconomic point of view, subsidies are largest in the case of the most expensive payment methods. The second externality is associated with the fact that the payment system generally consists of a chain of companies (e.g. shop-bank-industrial firm). As a result, disputes easily arise concerning the implementation of investments for developing the system because outlays on investment are usually focussed on the company carrying out the investment, whereas all the companies in the chain benefit from the investment. If no agreement is reached on the distribution of costs and benefits, the level of investment of the system easily remains too low. A third externality may arise from the fact that, when measuring the reliability and security of their payment systems, banks tend to assess the costs

arising from possible disturbances mainly from the point of view of their own activities. Probably banks do not take sufficiently into account the fact that disturbances in the systems of individual banks affect the confidence of economic agents in the functioning of the entire payment system. Hence, it is possible that, from the point of view of the economy, banks do not invest enough in ensuring the reliability and security of their payment systems. The central bank is able to mitigate the disadvantages of all these externalities through suitable control and support measures.

The fourth essay examines the effects of a change in the payment system on the efficiency of monetary policy. The analysis in the essay is based on the hypothesis that an increase in the efficiency of the payment system reduces the autonomous demand for money and increases the interest rate sensitivity of the demand for money.

First, attention is paid to the impact of the increased efficiency of the payment system on the autonomy of monetary policy in an open economy. It is shown that, if money and other domestic and foreign assets are gross substitutes, the increased efficiency of the payment system weakens the autonomy of monetary policy.

In the following section, the effects of the increased efficiency of the payment system on the effectiveness of monetary policy are examined. Generally speaking, the increased efficiency of the payment system seems to weaken the central bank's scope for smoothing real economic fluctuations in the economy. This result is obtained both in a model in which the opportunity of stabilizing the real economy arises through the Lucas mechanism and in a model in which the impact of counter-cyclical policy is based on wage rigidity.

The final section of the essay examines what kinds of effects two payment systems operating on different monetary standards can exert on cyclical fluctuations in the economy. The first of the payment systems compared is one in which monetary policy has no objectives and is described by a fully stochastic process. Such monetary policy can be thought to be associated, with for example, a fully competitive

commodity money system implemented by the private sector. In the other system, the central bank pursues monetary policy in a conventional fashion in order to attain its nominal and real objectives.

It is pointed out in the analysis that real economic fluctuations can be smaller in either monetary structure. In particular, when the central bank makes intensive efforts to reduce variations in the rate of inflation, real economic variations may be smaller in an economy guided by a "blind" monetary policy.

I PAYMENT SYSTEMS: THEORY AND REALITY

1 Introduction

The emergence of a money economy and payment systems can be seen as an
attempt by the economy to organize as efficiently as possible the
transfers of wealth necessitated by the exchange of commodities
between different agents. A payment system offers a means of replacing
barter by indirect, anonymous exchange in organized markets. The more
economically this exchange is carried out, the greater is the amount
of real resources released for the production of commodities and
services.

In economic theory, three different payment systems are distinguished:
the commodity money system, the fiat money system and the accounting
system of exchange. Although actual payment systems may have features
differing from those in these theoretical systems - which in their
pure forms are imaginary - an understanding of the properties of
theoretical systems is useful when examining the operating mechanisms
of systems in the real world. Consequently, the functioning,
advantages and drawbacks of these theoretical systems are described
and discussed in some detail in this essay.

Features of both the fiat money system and the accounting system are
frequently present in actual payment systems. Today, cash is still the
most widely used form of payment in different countries, although
features of the giro system can be expected to increase in payment
systems along with the development of payment transfer technology. For
example, in Finland more than 70 per cent of the economy's payments
are in cash. However, by international standards, only a small amount
of cash is used in Finland in relation to the size of the economy.
Indeed, a comparison with the payment systems of other countries reveals
that Finland is one of the leading countries in the introduction of
payment methods (such as bank and postal giro systems) with respect to
both technical facilities and banking services.

The above description does not tell us anything about the economic
efficiency of the system. The more efficient the payment system is,

the less economic resources it ties up. The macroeconomic costs
arising from the payment system can be regarded as a measure of its
economic efficiency. For example, cost-saving technical innovations in
the market for payment instruments have increased features of the giro
system in prevailing payment systems. The economic profitability of
these innovations will eventually determine whether the features
embodied in them will dominate payment systems permanently.

This essay examines problems related to payment systems from the point
of view of both theory and practice. The analysis is organized as
follows. Chapter 2 presents some considerations on the development and
characteristics of barter and monetary economies. Chapter 3 gives a
survey of theoretical payment systems. The special features of the
Finnish payment system are set out by means of an international
comparison in Chapter 4. Differences·in the cost of payment systems
generally and the costs of the Finnish payment system in particular
are discussed in Chapters 5 and 6.

2   Barter and Monetary Economies

The preconditions for monetary and payment systems in general came
into being with the shift from pure self-sufficiency of economic agents
to a barter economy. In its most primitive form, the exchange of goods
and services took place (and still does in certain contexts) as a
direct exchange between two agents. A necessary condition for barter
was that the two agents had a double coincidence of wants. There
existed no market institutions, so that individual market situations
arose between agents. The introduction of money or means of payment in
general in economies and the emergence of market institutions enabled
the implementation of exchange between economic agents anonymously in
organized markets.

The fundamental problem of a pure barter economy is the high level of
the various costs involved in barter. Agents have to use large amounts
of real resources for storing and transporting commodities and seeking
out trading partners. In many cases, the storage, transport and search

costs are so high as to preclude barter, self sufficiency being
preferred instead.

In a pure barter economy, the introduction of money or other means of
payment directly implies that the matching of the mutual needs of
economic agents becomes unnecessary. Economic agents are able to do
business directly with the market, receiving or spending money. The
market seeks out the other parties to the exchange. The use of money
for indirect exchange substantially reduces the search costs of
economic agents. The market implements the search more efficiently than
households, as economies of scale arise in the unit costs of search.

The use of means of payment as media of exchange also reduces other
costs of exchange. Economies of scale arise in transport when these
activities are transferred from individual agents to larger organizations.
Perhaps therefore the primary reason for the existence and development
of money and other means of payment is rationalization in the use of
resources: the use of means of payment makes it possible for the
exchange process in the economy to be organized so that real resources
are released for other purposes. Viewed from this perspective, the
development of means of payment resembles normal technical progress,
whereby the unit costs of transfers of assets required by the exchange
of commodities are reduced.[1]

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[1] The role of money in the economy and questions concerning the nature
and properties of the alternative payment systems are among the
traditional problems of monetary theory. An excellent collection of
readings on this topic, which has already become a classic, is Clower
(1969): the fundamental aspects of the efficiency issues relating to
barter and payment systems are clearly illuminated in the Introduction
by Clower and in Jevons' paper on the barter economy (1910) and Pigou's
paper on the money economy (1941). The efficiency of barter and payment
systems has subsequently been analyzed by Brunner - Meltzer (1971). This
in turn served as a basis for studies by King - Plosser (1986), who
placed particular emphasis on the savings in search and information
costs attributable to the monetary system, by Starr (1972), who proved
theoretically that the monetary system is at least as efficient as the
barter system, and by Ostroy - Starr (1974) and Norman (1987), who
further confirmed this result. See, also, Starr (1980).

The use of money and other means of payment also enhances the functioning of a pure barter economy by expanding the opportunities for exchange over time. In a pure barter economy it is difficult to conclude credible barter contracts over time. In such barter contracts, one of the parties surrenders commodities to the other at some point in time against a promise by the other party to deliver an agreed amount of commodities at an agreed time in the future. The problem related to contracts over time derives from the fact that in a pure barter economy there is no mechanism guaranteeing that a contract will always be fulfilled. The agent surrendering the commodities does so merely relying on the fact that the recipient will fulfill his part of the barter contract in the due course of time. Moreover, the recipient has no economic incentive to actually do so. On the contrary, it would pay him not to meet his commitment.

The efficiency of intertemporal contracts is substantially enhanced, if money or another means of payment is introduced in a pure barter economy. On surrendering a commodity to the market, the agent receives an equivalent amount of money, which he can use in accordance with his preferences to acquire the commodities he needs either immediately or in the future. Similarly, in order to pay for their purchases, buyers use money, which may be derived from sales proceeds received either previously or simultaneously. Hence the introduction of money eliminates the problem of credibility between two economic agents in intertemporal barter contracts by transforming these bilateral contracts into indirect contracts which are fulfilled in the market. The improvement in the intertemporal efficiency of the economy resulting from the introduction of money is also reflected in the fact that (if the storage of commodities or resources is possible) the economy is able, in net terms, either to save or temporarily overconsume.

However, the use of money and means of payment in the allocation of consumption over time also entails some problems. One problem arises from the fact that the future price of money is usually uncertain, so that the timing of consumption may depend on agents' attitudes to risk. Another problem is connected with the fact that the institution of money itself should be credible, so that agents can be confident in the

possibility to postpone consumption provided by it. This presupposes
certain properties on the part of the institution of money and its
organization. These requirements are dealt with below in the discussion
on different payment systems. Thirdly, it can be noted that,
particularly with respect to intertemporal effects, there are
alternatives to money and means of payment which may, in certain
respects, be more efficient instruments for the allocation of
consumption. For example, the government's tax and social security
system can, in principle, be used as an intertemporal transfer system.[2]

The two fundamental reasons given above for the introduction and
development of money and means of payment provide a sufficiently
detailed illustration here of the basic role of money in the economy.
Money and means of payment create an alternative exchange technology
in a decentralized economy[3] in which barter exchange is replaced by
indirect exchange in the market. This results in more efficient use of
resources in the economy: as the exchange takes place more economically,
resources are released for the production of commodities. Naturally an
exchange system based on means of payment also uses part of economic
resources, so that - contrary to the assumptions of traditional
monetary theory - money is not, generally speaking, a commodity that
can be produced free of cost. The possibility of technical progress
attaches to monetary systems. The development of means of payment and
institutions makes possible a reduction in the share of resources
required by the exchange system.

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[2]The idea of money as an institution enhancing intertemporal efficiency
was first formalized by Samuelson (1958). Important further studies
carried out on the basis of this view are Diamond (1965), Cass - Yaari
(1966), Wallace (1980) and Weil (1987).

[3]The opposite to a decentralized economy is a Walrasian centralized
exchange economy in which exchanges of commodities are centralized
both temporarily and geographically.

3 A Survey of Payment Systems

With the passing of time, payment systems have, of course, developed
in many respects. It is difficult to describe actual payment systems
in terms of general concepts, because they generally incorporate
several fundamental features which are conceptually different from
each other. In economic theory, three different payment systems are
distinguished nowadays: the commodity money system, the fiat money
system and the accounting system of exchange. An understanding of the
properties of and theoretical differences between these systems - no
matter if the systems themselves are, in their purest forms, imaginary
- is obviously very useful for gaining an insight into the modes of
operation and properties of mixed systems in the real world. In the
following, we omit the direct exchange of commodities from the
analysis and focus instead on the payment systems mentioned above.
These systems, the way in which they function, and their advantages
and drawbacks are described in some detail in the sections below.

3.1 Commodity Money System

The earliest payment systems were those in which commodity money was
used as a means of payment. As noted above, the commodity money system
was used to rationalize distribution by making the direct exchanges
between two parties unnecessary. Commodities could be traded in the
market for commodity money, whose purchasing power was acknowledged by
all economic agents.

The commodity money system is based on the fact that only the relative
prices of commodities are determined in the economy. Consequently, any
commodity in the economy could be chosen as the commodity money, i.e.
its price could be agreed on so that, for example, one gramme of the
commodity costs one unit of currency, and then the prices of all other
commodities and services could be measured in relation to the unit of
commodity money. The price of one gramme of the material could equally
well be set at 100 units of currency, in which case the relative
prices of all other goods would increase one hundred-fold, the
relative prices of commodities nevertheless remaining unchanged.

In theory, a commodity money system could function as either a direct or an indirect system. If the material (e.g. historic gold coins) chosen as the unit of account is used exclusively as a means of payment in the economy, the rate of exchange between each commodity and gold coins directly indicates the value of the commodity in terms of gold. If, however, pieces of paper with a value of, say, 10 grammes of gold are used as means of payment, the rates of exchange between commodities and the pieces of paper also indirectly determine the prices of commodities in terms of units of gold.

A necessary condition for the flowless functioning of an indirect commodity money system is that continuous two-way convertibility prevails between the means of payment and the material defined as the actual commodity money. Although the option of convertibility may not be frequently exercised for practical reasons (e.g. when different countries put their monetary systems on the gold standard, the gold forming the basis for the system remained mainly in the hands of governments), it is necessary so as to guarantee the credibility of the system under any circumstances.

To guarantee convertibility it is necessary to store the commodity constituting the basis for the system. For convertibility to be possible under all conceivable circumstances, stocks should correspond to 100 per cent of the nominal value of the means of payment in circulation.

The material serving as the base for the measurement of values is in demand, not only for reserves, but also for industrial use. Material is produced in a normal fashion using a production process typical of the respective material (e.g. prospecting, mining and refining of ores). If the supply of the material (equals deliveries of material for uses other than reserves equals output of the material less net increase in stocks) increases more than the (industrial) demand for material, the material becomes cheaper in relation to other goods (assuming no changes in their supply and demand). This is reflected in the commodity money system in a rise in the prices of other goods, i.e. inflation occurs in the economy. By contrast, if the supply of

the material in relation to its demand diminishes, other commodities become cheaper in relation to the material and there is a fall in the general price level, i.e. deflation, in the economy.[4]

The relative prices of other commodities do not change along with fluctuations in the supply of the material used as the commodity money, provided that all prices in the economy are perfectly elastic. If, on the other hand, the price system of the economy is subject to adjustment rigidities, variations in the general price level may also lead to fluctuations in relative prices.

Units of some precious metal, e.g. gold or silver, have generally been used as the unit of account for commodity money systems. In the early stages of such systems, the unit of account was also used as a means of payment, so that payments in the economy were effected in the form of gold or silver coins, for example. Later instruments were introduced for effecting payments - notes, cheques, etc. - in which case the value of means of payment was guaranteed by full convertibility. Depending on the unit of account used this system was called, for example, the gold or silver standard. Fixed exchange rate systems can also be interpreted as commodity money systems to a certain degree: under them, a foreign currency can always be converted into other currencies at fixed prices.[5]

In recent years, the commodity money system has experienced some kind of renaissance in economic research (see Hall (1982), White (1983, 1984), McCallum (1985)). The popularity of the idea is associated with the general trend in macroeconomic research in recent years, which has often focussed on the disturbances which the demand management policy pursued by the government can give rise to in the economy. In these

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[4]Barro's study (1979) contains a lucid analysis of the determination of the price level under a commodity money (the gold standard) system.

[5]For a comprehensive exposition on commodity money systems - including an analysis of fixed exchange rate system as a commodity money system - see Friedman (1951). Other good general sources are Niehans (1978), Chapter 8, Hall (1982), White (1984), McCallum (1985), Fischer (1986b) and Selgin - White (1987).

analyses, particularly the central bank's money supply rule has often been regarded as a significant factor contributing to inflation and (thereby) to economic fluctuations. Commodity money systems are also arousing interest in practical economic policy. In September 1987, James Baker, the US secretary of the treasury, proposed the introduction of a commodity money system as a basis for and a means of stabilizing the international monetary system.

The commodity money system is regarded as having two significant advantages conducive to keeping the economy free of disturbances. First, under the commodity money system, it is not necessary for governments to intervene in the regulation of the supply of money in order to ensure the stability of the monetary economy. Even if the central bank were to regulate the supply of money fully optimally, it would not be able to function more efficiently than a competitive economy. Hence, by privatizing the payment system, it is possible to avoid the risk that the central bank would not able to pursue an optimal money supply policy. The second advantage of the commodity money system is that it allows the introduction of a commodity basket which, for example, stabilizes the rate of change in the consumer price index as well as possible.

One of the best-known commodity basket proposals is the ANCAP standard of Hall (1982), the composition of which is determined so that 33 per cent of its value (at 1967 prices) is ammonium nitrate, 12 per cent copper, 36 per cent aluminium and 19 per cent plywood. According to the ANCAP standard, the dollar should be defined in terms of this commodity basket so that the combined price of the four commodities was one dollar in 1967. Hall states that had the dollar been defined in this way the consumer price index would have remained virtually unchanged throughout the postwar period in the USA. The stability of the index could have been increased still further by gradually readjusting the weights of the basket over time. Then it would have been possible to achieve a zero rate of inflation.

If the aim is to get as close as possible to a zero rate of inflation under a commodity standard, then the simplest way would be to define a

certain amount of the commodities in the basket constituting the basis for the consumer price index as the unit of account. By definition, the consumer price index would then remain unchanged as long as convertibility guaranteed the value of the means of payment.

In its developed form (commodity basket money), the commodity money system would therefore seem to offer major benefits. As stated above, the general price level is of no importance in the economy, if the adjustment of relative prices is flexible. However, most economists probably agree that significant price rigidities (e.g. wage and price agreements) exist, so that the price level and the rate of inflation also exert real effects on the economy. Fluctuations in the rate of inflation, in particular, affect the real economy, since they force agents to alter their assessments of the situation as well as their decisions.

However, commodity money systems also involve distinct disadvantages. As stated above, in simple systems - for example, gold coin or gold standard economies - the fundamental problem is that the price level is affected by the production of the basic material. So as to be able to stabilize the price level in simple systems, the central bank (or other agents in charge of the money supply) should regulate the supply of the basic material in the market by adjusting its own material reserves whenever the need arises. This requires that, even under a pure gold standard, the central bank must hold gold reserves in order to stabilize the price level.

Under all systems based on convertibility, the holding of material reserves is necessary merely from the point of view of the functioning of the system. The holding of reserves entails costs, which vary greatly depending on the basic material used by the system. Costs also arise because part of the real resources of the economy are not available for alternative use while they are held in store.

Storage costs are likely to be reasonable, if a precious metal serves as the basic material in the system. It is perhaps precisely for this reason that precious metals have been the most widely used standard

for monetary systems in the past. If, instead, a commodity basket consisting of ordinary goods or raw materials were to be used as the basic material in the system, the storage costs would be considerable. The storage problems associated with the space requirements, perishability, transportability and other special features of commodities would be the greater, the more diversified the commodity basket in question. Storing the resources comprising the commodity basket for the consumer price index to the extent necessary for the stability of the monetary system would in all likelihood be so expensive that the benefits gained by the elimination of inflation would be more than offset by storage costs. Political risks may also attach to simple commodity money systems, because the supply of the basic material may involve some degree of monopoly power. For example, as regards gold production, two countries (South Africa and the Soviet Union) have such large market shares that they can certainly affect the market price of gold whenever they wish and hence the prices of commodities in different countries if these countries' monetary systems are based on the gold standard.

In systems based on diversified commodity baskets, additional problems may arise through the mechanism of convertibility itself. If, in such a system, a difference should emerge - for one reason or another - between the market price of money and the price expressed in terms of the announced commodity basket, it means that part of the payments would be effected by first exchanging the means of payment into goods at the government storehouse. In that case, some recipients of payments would be forced to start accepting goods as payment. However, this would not necessarily take place entirely without friction, because it would also require substantial storage capacity on the part of individual agents. Then the mechanism of convertibility would probably not be able to carry out the function for which it constitutes part of the system. Money could have two or even several prices, nor would there be sufficient arbitrage in the market to eliminate price differences.

3.2   The Fiat Money System

If an object whose intrinsic value in terms of production costs is low
and which is not convertible into any commodity or commodity basket is
used as a means of payment, it is said to be fiat money. If, for
example, the material and labour inputs needed for producing a note of
500 units of currency cost one unit altogether, then this note can be
used to buy 500 times the amount of these inputs in the market. In
other words, the value of the note as a means of payment is 500 times
that of its value as a commodity.[6]

A payment system operating on the basis of fiat money can operate
without severe disturbances only as long as economic agents believe
and have confidence in the sustainability of the system.[7] This
requires, above all, that all private individuals and companies are
confident that the means of payment at their disposal are accepted in
transactions at their nominal values. In order to enhance confidence,
fiat money systems are usually complemented by the institution of
legal tender. This is formed by laying down in law that a liability
can be discharged if the debtor has paid or proven his willingness to
pay the amount of the liability in legal tender.

Today, the fiat money system probably does not operate anywhere in its
pure form, a form in which money is the sole means of payment. In
market economies, many close substitutes for fiat money have been
developed including, for example, cheque accounts and some time
deposits. It is estimated that, as a rule, a very close relationship
exists between the amounts of alternative means of payment and base

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[6]The fiat money system lies at the basis of neoclassical monetary
theory. Hence, inherent in all macromodels incorporating a monetary
economy is the assumption of fiat money, the amount of which can be
changed without cost. The problem of the determination of the market
price of fiat money (i.e. the price gap between the market price and
production costs) has been one of the major theoretical issues of the
neoclassical model, see Niehans (1978), Chapter 1, and Samuelson (1968).

[7]This question will be taken up again further in the third essay, see
Obstfeld-Rogoff (1983) and Weil (1987).

money.[8] Depending on the role and operating methods of the central
bank, the relationship is determined either through cash reserve
requirements or through the cash management policies of institutions
actually engaged in intermediation. In addition to alternative payment
methods based on deposits, payment methods (credit cards etc) based on
short-term borrowing have also been developed recently.

Under the fiat money system, the price level is thought to be
determined in exactly the same way as under the commodity money
system. If fiat money is the only means of payment in use and if the
supply of and demand for commodities and services remain unchanged,
the supply of money directly determines changes in the price level. If
the supply of money increases, its value in relation to commodities
falls and inflation appears in the economy. Deflation is possible if
the supply of money decreases.

If fiat money has several substitutes of various degrees, the
determination of the price level is in principle similar. A fairly
stable - albeit statistical - relationship exists between the price
level and some broad monetary aggregate. Similarly, there prevails
some statistical relationship between the substitutes for money
included in broad money and base money itself. However, the emergence
of substitutes in the market creates adjustment opportunities, as a
result of which the relationship between narrow money and the price
level may no longer be as precise as it might have been in the simple
basic situation.

The determination of the general price level is of course affecetd by
all those factors which give rise to changes in the relative prices of
commodities included in the consumer price index. These include, among
other things, changes in the amounts of basic resources, technological
progress and changes in consumers' preferences. Consequently, the
above description of the relationship between the price level and the
money supply only applies to a situation in which all other factors
remain unchanged.

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[8]See Chapter 2.2 in the second essay.

Payment·systems based on fiat money have in fact come into being as a
result of a commodity money system being abandoned by abolishing the
convertibility of money and by partly or totally ceasing to maintain
back-up stocks. Usually commodity money systems have been abandoned
because the maintenance of sufficiently large back-up stocks has no
longer been considered to be feasible owing to storage costs, the
availability of materials or some other reason. Economic agents, who
under the gold standard seldom utilized the opportunity of convertibility,
did not perceive significant changes in the economy as a consequence
of the abandonment of the standard. Their belief in the functioning of
the system - i.e. in the correct measurement of relative prices and an
efficient and secure transfer of wealth - remained. This contributed to
the fact that the system was not subject to self-fulfilling speculative
pressures, which could have been fateful for a system based on
confidence. In spite of radical structural change, economies continued
to function more or less as before. For example, is very difficult to
point to any marked price effects which can be shown to be attributable
to structural change.[9]

From the theoretical point of view, the fact that radical structural
change has had only minor effects on the workings of the economy may
seem somewhat surprising. If, for example, we construct an imaginary
economy where, under prevailing barter economy conditions, the
government or private banks were to offer economic agents a new
payment and wealth transfer technique in which transfers were
implemented by means of fiat money, the supplier of the system would
certainly encounter very great difficulties in gaining the public's
confidence. The main reasons why there are only minor effects may be
associated with the real benefits of the fiat money system, which
economic agents have observed either directly or indirectly. If
economic agents were to lose their confidence in the monetary system
to the extent that it collapsed, they would have to pay the losses

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[9]Bordo (1986a) presents historical empirical data for various countries
on the stability of rates of inflation under different monetary regimes
systems. To some extent, the data suggest, that, under commodity money
systems, rates of inflation have been, on average, both lower and more
easily predictable than under fiat money systems.

arising from the introduction of the next most efficient payment
system (see Weil (1987)).

A payment system based on the use of fiat money allows economic agents
to have transactions with the market and makes it unnecessary for the
parties to transactions to have matching wants. In this respect, the
system does not differ from the commodity money system. In their
developed forms, in which technically sophisticated means of payment
are used in both systems, the systems of fiat money and commodity
money still function very similarly to each other.

Economically, the systems differ from each other in a significant way
mainly because of differences in real storage costs. Under a fiat
money system, storage costs are substantially lower than under
commodity money systems pegged to commodity baskets. In the latter
case, merely the physical need for storage space and potential
problems related to preserving commodities give rise to major costs.
If the convertibility mechanism is utilized frequently, the storage
problems also touch economic agents other than the central bank or
commercial banks. On the other hand, the storage costs under a
commodity money system may be relatively low, if some non-perishable
and precious material requiring little space is used as the basic
material and if convertibility is not utilized frequently. This may
have been the case, for example, under the US gold standard during its
latter years in operation. All commodity money systems nevertheless
involve an additional cost, which is due to the fact that the material
used as money is demanded for purposes other than just storage. And it
is precisely on this demand that the value of the material in relation
to other commodities is based. Storage as a back-up for the monetary
system ties up part - probably a substantial part - of the total
supply of material and puts it beyond the reach of other demand. In a
sense, the economy pays a real resource tax for maintaining a payment
system based on commodity money and a convertibility mechanism. A
similar resource tax is also associated with fiat money systems,
although to a much smaller extent than under commodity money systems.
Under a fiat money system, the resource tax mainly arises from the
fact that the functioning of the system requires the tying up of
labour and capital resources.

Taken as a whole, a fiat money system would appear to possess advantages over any payment system based on the use of commodity money. However, the principle of fiat money gives rise to a potential source of disturbances in the system, the effects of which can be extensive. Problems may arise because of the link between the supply of money and the price level described above. To a large degree, the problems are related to the question of by whom and how the payment system is organized.[10]

Irrespective of whether the supply of base money is under the control of the government or the private sector, the supply of money and thereby the price level (and possibly real phenomena as well), in the fashion described above, are under the political influence of some decision-making unit. When planning their activities and making decisions economic agents must assess how the authority controlling the supply of base money will behave. This feature distinguishes fiat and commodity money systems from each other, because in the latter the money supply mechanism is, with the exception of the storage policy concerning commodity money, controlled by exogenous factors.

In principle it is possible under a fiat money system that the controller of the money supply acts in such a way that the price level prevailing in the economy follows the same time path as that under some commodity money system. However, this is only one potential path among an infinite number of many others. Moreover, there are strong grounds for claiming that a neutral policy of money supply such as this is not necessarily the most likely alternative. If the supply of money is controlled by banks operating under competitive conditions, it is precisely the fact that money is unbacked which creates a strong economic incentive for banks to issue very large amounts of money. In fact, this incentive remains positive at the margin as long as money is unbacked, i.e. as long as the purchasing power of money in the market exceeds its production costs per unit.

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[10]This question will be discussed in more detail below in the third essay.

In a frictionless economy, the existence of an incentive always prompts immediate action by profit-maximizing economic agents, in which case a short period of hyperinflation would emerge in the economy. In such a theoretical economy, the price level would rise rapidly so that the purchasing power of the means of payment would correspond to its production costs in terms of real resources. Thereafter, only occasional disturbances would affect the price level and the supply of money would grow, on average, at the same rate as the rest of the economy. Thus, if organized along competitive lines, a fiat money system is unsustainable and, sooner or later, literally returns to a paper standard.

Of course, an economic incentive to exploit the fact that money is unbacked also arises in the case where the central bank (the government) manages the supply of money. However, the role of the central bank differs from that of competing banks in that the central bank, as a monopoly, must take into account the effects of money supply on the price level, which individual competing banks would not necessarily do. Hence, the central bank must weigh the monopoly profits which it can obtain as a result of money being unbacked against the additional real resources needed for the production of money and the maintenance and possible replacement of the payment system because of the depreciation of money.

In the real world, central banks have been fairly moderate in their money supply policy, at least compared with what would happen in frictionless competitive conditions. On the other hand, it can also be noted that there are no economies in which zero inflation has been achieved, at least in the longer term. From the point of view of narrow monetaristic interpretation, this implies that the government has not been able to avoid the "temptation" inherent in the institution of fiat money, and has used note printing and the inflation tax for financing the state's budget deficits.

Accordingly, the very fact that money is unbacked seems to impose the constraint on a fiat money system that, in the longer run, the system cannot be operated solely by competing private companies. The

government is needed so that the property of fiat money contributing to the more efficient use of resources can be maintained. This intervention argument may, throughout the history of the monetary economy, have been the foundation on which the state's monopoly in money supply has been based. Even such committed supporters of competitive economies as M. Friedman (1959) and D. Patinkin (1965) have accepted this argument. Certain objections have, of course, been raised. The best-known is probably the critique of intervention put forward by B. Klein (1974). He states that if individual banks each provided their own currencies in the market, they would themselves be forced to ensure the "quality" (i.e. purchasing power) of their currencies, whereupon excessive money supply would be eliminated.

3.3 Accounting System of Exchange

Both the commodity and fiat money systems are characterized by the fact that the unit of account also serves as a means of payment. Under these systems, all payment instruments can be understood as either fractions of the basic unit of account or multiples thereof. Consequently, the stock of units of account can be interpreted as either a monetary base or cover for means of payment, and price formation and real phenomena in the economy can be analyzed from the point of view of fluctuations in this stock.

Under an accounting system of exchange, i.e. a payment system based on the use of transfers between accounts, the above-mentioned link between the unit of account and means of payment does not exist. In an accounting system, any commodity or raw material for which there is demand in the economy can be used as the basis for measuring values. The only requirement is that all economic agents apply the same unit of account (the "numeraire" commodity). When all commodities, raw materials, services, securities, liabilities and other similar economic relations are constantly evaluated in terms of the numeraire commodity, the transfers of wealth connected with purchases, sales and

changes in wealth relations can be effected using any technically
efficient method.[11]

Probably the best-known description of a system for transferring
wealth is the "BFH" accounting system of exchange (Black (1970), Fama
(1980), Hall (1983)). The system is based on the notion that banks
have two functions in the economy. On the one hand, banks are mutual
funds which receive deposits and then invest them in the form of
loans, shares, bonds and debentures, etc. On the other hand, banks
render wealth transfer services to economic agents by effecting
transfers from one agent to another according to their instructions.
Under certain conditions of production, these functions could be
separated from each other so that the portfolio management unit and
the transfer unit operate as separate companies, utilizing the
services of each other whenever needed.

In the balance sheet of the portfolio management unit, deposits and
investments are priced in terms of the numeraire commodity at market
prices. When an economic agent wishes to effect a payment to another
agent, it instructs the bank's portfolio management unit to transfer
the required amount of wealth (either deposits or credit) to the
recipient of the payment.[12] The portfolio management unit purchases
wealth transfer services from the transfer unit at market prices and
carries out the payment order, if the issuer of the order has a
sufficient amount of deposits or borrowed wealth at his disposal.
Finally, the portfolio management unit charges the payer for the
transfer cost and for its own market-priced commission.

Two essential characterics are associated with payments under an
accounting system of exchange. First, in principle, transferable

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[11]The accounting system of exchange has been dealt with, inter alia, by
Black (1970), Fama (1980), Hall (1983), McCallum (1985), White (1984),
Yeager (1983) and Goodhart (1987).

[12]Wicksell's (1936) developed credit economy is an institutional
arrangement similar to an accounting system of exchange including
credit limit facilities.

wealth is always a market-priced share of the bank's balance sheet and hence - provided that its pricing is correct - fully covered. In this sense, the accounting system of exchange corresponds to the commodity money system and does not involve the same risk of instability in the price level as the system of fiat money. Secondly, the transfer of wealth is by its nature a transfer service, which is rendered at market prices. Accordingly, the transfer of wealth is normal business activity, which takes place under normal assumptions concerning corporate activity. Viewed as a whole, the production of payment services in an accounting system of exchange is carried out under conditions which superficially do not differ at all from the normal productive activities of a market economy. From the outset, the developers of the accounting system of exchange have used this feature as an argument in favour of a fully privatized payment system and free banking. The third essay below puts forward a number of micro-theoretical arguments on the basis of which opposite views about these questions can be presented.

The accounting system of exchange possesses several benefits as a payment system. In principle, it is entirely independent of the techniques of wealth transfer, so that the method of payment transfer which is the most suitable from the point of view of each stage of technical development can be applied to it. Above all, this system is particularly suited to the computerized transfer of payments. As a consequence, it may be possible through the accounting system of exchange to achieve total costs which are lower (or at least as low) as those in any other payment system. In addition, the basis for measuring prices in the accounts system can be chosen so that prices stabilize. In any case, the control of prices is not directly in the hands of those pursuing economic policy (the central bank); rather it is exogenous from the point of view of an individual economic agent. The accounting system of exchange partly reduces economic agents' risks in the sense that banks' portfolios are likely to be well diversified, leaving only systematic market risks to be incurred by the holders of the funds. However, this benefit is significant only under conditions of imperfect financial markets, whereas in perfect markets investors hedge themselves against unsystematic risks.

Finally, the accounting system of exchange is advantageous in the sense that although the means of payment in the system are fully covered, cover is not based on convertibility. Hence, the maintenance of stocks guaranteeing convertibility is not necessary and reserve commodities and other resources which would otherwise be tied up in stocks are used for other economic purposes.

Despite its many advantages, there are nevertheless some doubts about the practical implementation of the accounting system of exchange. It is somewhat unclear in what way and how well the system would function in practice, because under a pure system, transfers of wealth can only be effected in the form of changes in account entries. Under highly developed systems, the only indication of a transaction might be a change in the computer register. In addition, transfers of wealth might possibly consist of transfers of portfolio units which continually fluctuate in value. Irrespective of the institutional system, these transfers should be evaluated on the same basis, i.e. using the same numeraire commodity or commodity basket. The entire setting is claimed to resemble an abstract situation in which the famous imaginary institution, the Walrasian auctioneer, organizes the market, quotes prices and effects transactions free of cost.

It is claimed that a good many of the fundamental benefits of the accounting system of exchange would not be achieved if the system were not perfect and some minor amount of fiat money circulated in the economy. In that case, it would most likely be necessary to use the basic unit of fiat money as a unit of account. This could lead to bias in pricing and thus eliminate full coverage of transfers between accounts (see McCallum (1985)).

4   The Finnish Payment System: an International Comparison

The properties and main differences of three types of payment system
were presented above. In their purest forms the systems described are
theoretical simplifications of payment systems functioning in the real
world, where the basic features of these different theoretical systems
are generally combined in a functioning whole. For example, payment
systems existing in different countries frequently include features of
both the fiat money system and the accounting system of exchange. At
present, the use of cash is still very widespread in different countries,
but with the development of payment transmission technology, features
of the accounting system of exchange can be expected to become
increasingly common in payment systems. In the following, the special
features of the Finnish payment system are examined and compared with
the systems applied in other countries. A good international benchmark
for comparing the Finnish payment system is provided by the study
"Payment Systems in Eleven Developed Countries" published by the Bank
for International Settlements (BIS) in 1985. In the following, data
from this study are compared with corresponding data on the Finnish
payment system. The source material on Finland is drawn from general
statistical data and data appearing in the report "Payment Systems and
Banking Technology in Finland", published by the Finnish Bankers'
Association in 1986.

Generally speaking, cash is an important means of payment in the
payment systems of various countries. For example, in Finland more
than 70 per cent of all transactions in the economy are effected using
cash. However, this figure does not give an entirely accurate picture
of the role of cash in the Finnish payment system, since cash and
other payment methods are used in quite different situations. Cash is
primarily used by consumers for payment of minor purchases in retail
outlets whereas companies and the rest of the economy mainly rely on
other instruments for effecting their payments. In fact, a very small
amount of cash is used in Finland in relation to the size of the
economy. Table 1 shows the use of cash in Finland and in eleven other
countries in 1983.

TABLE 1. THE CASH UTILIZATION RATE IN VARIOUS COUNTRIES IN 1983,[1]
PERCENTAGE OF GDP

	Currency, %	Transferable deposits, %	M3 %
Belgium	9.9	14.0	180.7
The Netherlands	6.5	13.1	68.4
United Kingdom	4.0	29.0	33.0
Italy	6.4	4.6	95.9
Japan	7.6	22.2	150.3
Canada	3.2	9.6	46.8
France	5.1	20.9	75.1
Sweden	6.0	54.0	60.0
Germany	6.0	12.0	53.0
Finland	2.4	5.0	44.0
Switzerland	10.0	19.0	117.0
United States	4.2	31.9	75.4

[1] (BIS (1985), for countries other than Finland; Finnish data
are compiled from the Bank of Finland's database.

Table 1 shows that Finland has by far the lowest cash utilization rate
of all the countries compared. The United Kingdom, Canada and the
United States also seem to be countries with a low utilization rate.
In Finland, notes and coin accounted for 2.4 per cent of GDP in 1983,
whereas in Swizerland, for example, the corresponding figure was 10
per cent. In the year of comparison, Finland also had the lowest ratio
of sight deposits to GDP, 5 per cent. In Sweden, the corresponding
ratio was as high as 54 per cent. Finland had the second lowest (44
per cent) ratio of M3 (in addition to cash, M3 includes sight and time
deposits) to GDP, the highest ratio (180.7 per cent) being in Belgium.
All in all, Table 1 shows great variations in the cash utilization
rates of different countries. A high cash utilization rate points to
widespread use of traditional means of payment in the countries compared.

The low figures for the cash utilization rate in Finland largely
reflect Finland's highly developed bank and postal giro system. Both
companies and private individuals make widespread use of giro transfers
for effecting their payments. This is evident in Table 2, which shows
the use of new payment methods replacing cash in various countries.

TABLE 2.   USE OF NEW PAYMENT METHODS IN VARIOUS COUNTRIES,[1]
          PERCENTAGE OF TOTAL VOLUME OF TRANSACTIONS

	Cheques	Credit transfers and direct debits	Payments by credit cards
	%	%	%
Belgium	..	..	..
The Netherlands	22.3	77.6	0.1
United Kingdom	61.0	29.0	8.0
Italy	85.3	14.2	0.5
Japan	18.7	71.0	10.3
Canada	91.0	2.0	7.0
France	82.5	15.4	2.1
Sweden	20.0	73.0	7.0
Germany	11.0	89.0	0.0
Finland	11.7	78.6	9.7
Switzerland	10.6	88.8	0.6
United States	98.6[2]	1.4	7.2

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[1] BIS (1985) and the Finnish Bankers' Association (1986). Finnish data refer to the year 1985, while data on other countries refer to the year 1983. There is no precise data available on payments by credit card in Finland. In the present calculation, it is estimated that car-based payments in Finland totalled about 53 million in 1985. This figure includes bank card payments (23 million; the Finnish Bankers' Association, 1986); in other respects, the estimate is based on information obtained on the breakdown of the use of various means of payment in retail trade.

[2] Including credit card payments.

.. = not available.

Table 2 shows that the bank and postal giro system handles most of the cashless transactions in Finland; about 79 per cent of transactions are effected through the giro system. By international standards, the use of cheques in Finland is modest. For example, in Canada and the United States cheques account for more than 90 per cent of the transactions effected by means of cashless techniques whereas in Finland the corresponding figure was about 11 per cent. In fact, it seems that in Finland the use of cheques has been declining as a result of the growing prevalence of credit cards. In 1985, the number of cheque payments fell by 8 million, while the number of card-based payments grew by 12 million. This is also evident in the figures in Table 2, according to which the use of credit cards seems to be fairly widespread in Finland compared with other countries.

It is also interesting to compare the banking and payment services
provided by the banking sector in different countries. The banking
facilities available vary from country to country and their use is
already partly reflected in the figures in Tables 1 and 2. Although it
is very difficult, if not impossible, to measure the quality of
banking services in the countries compared, certain indicators of the
volumes of services do exist. Table 3 shows a comparison of banking
facilities and the volumes of services in Finland and other countries
in terms of four indicators.

TABLE 3.   BANKING FACILITIES AND SERVICES IN DIFFERENT COUNTRIES[1]

	Inhabitants per			Number of transferable
	Branch	Cash dispenser or ATM	Terminal	deposit accounts for inhabitant
Belgium	968	17595	11209	0.8
The Netherlands	2222	..	..	0.9
United Kingdom	2283	9659	..	1.8
Italy	4398	37866	..	0.3
Japan	2780	3127	23700	..
Canada	1943	12755	..	1.6
France	1524	10940	5470	0.8
Sweden	2318	7700	11900	3.0
Germany	1541	38500	25000[2]	0.9
Finland	1440	7112	50000	3.5
Switzerland	1300	6329	..	0.5
United States	2310	4896	294500	0.3

[1] BIS (1985) and the Finnish Bankers' Association (1986). Finnish
    data defer to the year 1985, while data on other countries refer to
    the year 1983.

[2] In Munich only.

.. = not available.

Table 3 shows that Belgium, Finland and Switzerland have the densest
branch networks in relation to the country's population. Japan, the
United States, Switzerland and Finland have invested most in cash
dispensers and ATMs. France has the densest EFT POS terminal network,
whereas the country's low figure for card-based payments (Table 2)
suggests that the rate of utilization of the terminal network is not
very high in France. In Finland and Sweden, the number of transferable

deposit accounts per person is substantially higher than in other countries, reflecting the highly developed bank and postal giro systems in these countries.

In order to obtain an overall picture of the payment systems in the 12 countries compared, the countries have been ranked according to three criteria: the rate of cash utilization, the use of new payment methods and the level of banking facilities and services. The ranking is based on the data in Tables 1 - 3 and the results are shown in Table 4.

TABLE 4.   OVERALL COMPARISON OF PAYMENT SYSTEMS

	Total	Rate of cash utilization	Use of new payment methods	Banking facilities and services
1. Finland	3	1	1	1
2. United Kingdom	15	6	6	3
3. France	16	3	8	5
4. Sweden	17	4	5	8
5. Germany	17	9	4	4
6. Switzerland	18	7	2	9
7. Japan	19	5	2	12
8. Canada	19	8	9	2
9. The Netherlands	21	9	7	5
10. Belgium	23	2	12	9
11. United States	28	11	10	7
12. Italy	32	12	11	9

The figures in Table 4 should be interpreted as follows: The lower the ranking in Column 2 (rate of cash utilization) the smaller is the money supply in relation to GDP in the country concerned. The lower the ranking in Column 3 (use of new payment methods) the greater is the number of transactions based on the giro system. The lower is the ranking in Column 4 (banking facilities and services) the more developed are the techiques and the more diversified are the banking services at the disposal of banks' customers. In Column 1 (total), the ranking in Columns 2 - 4 have been added together and reported in ascending order.[13]

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[13]However, it should be noted here that the reference year (1985) used for Finland in Tables 2 - 3 is two years later than that of the other countries.

As can be seen from Table 4, the sum of the rankings received by Finland (3) is the lowest among the 12 countries. Thus, if the chosen criteria provide a correct measure, Finland is the top country among those compared as regards the use of new payment methods and the level of banking facilities and services. The Finnish payment system makes the lowest use of cash and cheques and the greatest use of other credit transfer instruments (bank and postal giros). In addition, the Finnish system seems to provide a dense and technically advanced network of services. These conclusions accord well with conventional views on the Finnish banking market, according to which Finland's oligopolistic banking market has tended to generate overcapacity and compete in terms of quality and volume of services rather than through prices.

The above conclusions should be treated with some caution, however. First, the comparisons made in terms of rankings do not indicate anything about the magnitude of differences. Secondly, the indicators available and the interpretations based on them are not necessarily the best possible combinations for describing differences in payment systems. For example, the indicators are not able to tell us anything about the quality of banking services. Moreover, it is impossible on the basis of the available information to give an estimate of how rapidly and safely any transaction can be effected in different countries. Nor do the comparisons reveal anything about the economic efficiency of different payment systems in different countries. Of particular interest here are questions concerning the magnitude of the unit costs of different transactions and the resources tied up by the payment system in different countries. However, as far as can be ascertained, there does not seem to be any international comparative data available on these issues.

5 Cost.Differences of Payment Systems

One of the major functions of a payment system is to operate as a
transfer system for effecting transfers of wealth between different
economic units. In this capacity, the payment system should function
as efficiently as possible. If the payment system comes into being
through market forces, the efficiency requirement is likely to be met
automatically. If, on the other hand, the payment system requires
intervention by the authorities the criterion of economic efficiency
will not necessarily be realized. No matter how the payment system is
implemented, it can be viewed as an investment associated with the
provision of payment transfer services. Since all payment systems
provide basically similar services, investment and operating costs are
important criteria in the comparison of systems. If one payment system
is able to provide the same transfer services more cheaply than other
systems, the pressures for adopting this system will be great. For
example, the recent technological innovations in the market for
payment instruments have increased features of the accounting system
of exchange in existing payment systems. The profitability of new
investments will ultimately determine which basic system the present
payment systems will come to resemble most.

The investment and operating costs attached to different payment
systems are outlined in Charts 1 and 2. Chart 1 depicts the
circulation of money and potential operating costs under the commodity
and fiat money systems.

Chart 1 shows that in both the commodity money and the fiat money
systems the circulation of money can be thought to take place through
three different stages. Money is produced and stored in the first
stage, distributed in the second stage and used in the third stage.
Security and storage costs are incurred at each stage, while transfer
costs arise when moving from one stage to an other. In the commodity
money system, these costs may prove unsustainable. In the fiat money
system, particularly security and R&D costs could rise to very high
levels with the development of counterfeiting technology.

CHART 1. CIRCULATION OF MONEY AND COSTS IN THE COMMODITY AND
FIAT MONEY SYSTEMS

PRODUCTION AND STORAGE OF MONEY
- production costs
- R&D costs
- security costs
- storage costs

transfer costs

transfer costs

DISTRIBUTION OF MONEY
- maintenance costs
- security costs
- storage costs

transfer costs

UTILIZATION OF MONEY
- security costs
- storage costs
- transfer costs
  (buyer → seller)

transfer costs
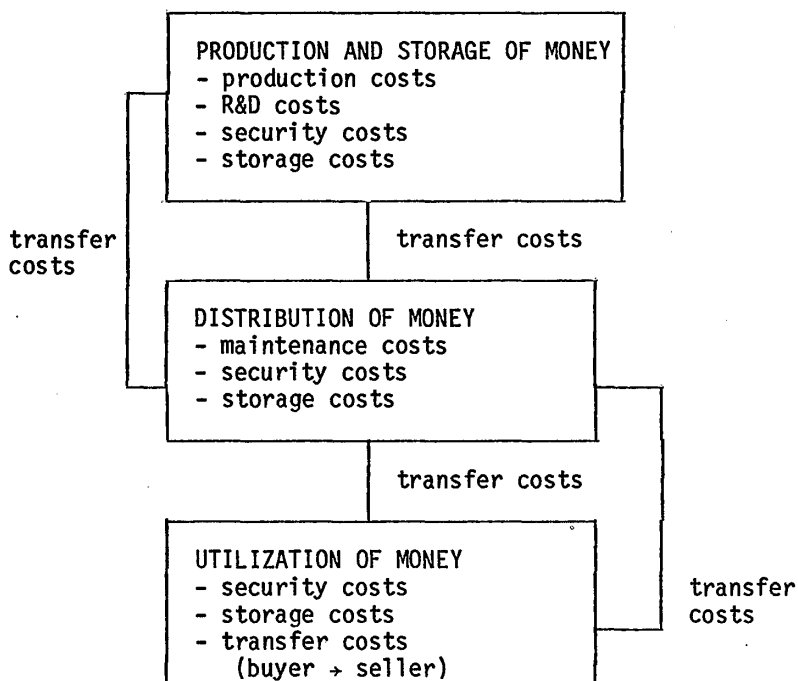
CHART 2. COSTS IN THE ACCOUNTING SYSTEM OF EXCHANGE

GIRO CENTRE
- costs related to the measurement
  of values
- maintenance costs
- security costs

UTILIZATION OF GIRO UNIT
- giro costs
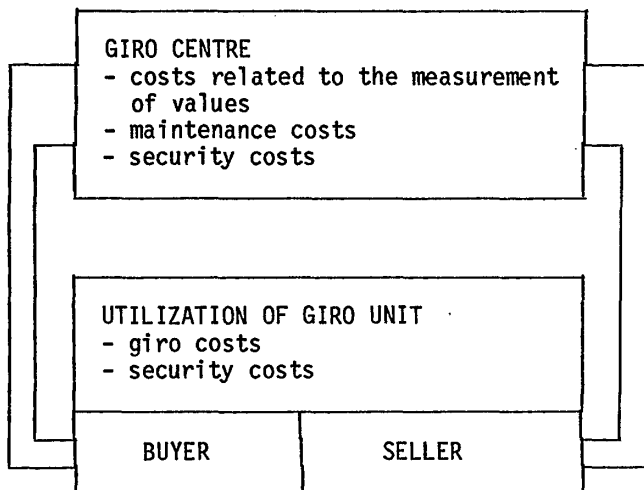- security costs

BUYER   SELLER

Chart 2 illustrates the potential costs arising in connection with the accounting system of exchange.

According to Chart 2, the accounting system of exchange is a two-stage system: the giro centre effects the transfers of wealth necessitated by the exchange of goods and services between economic agents. The production, storage, distribution and transfer costs appearing in the commodity and fiat money systems do not arise in the accounting system of exchange. By contrast, as there is no direct relationship in this system between the basis for measuring values and media of exchange, additional costs are incurred in connection with the measurement of values. Chart 2 seems to indicate that, in terms of its cost structure, the accounting system of exchange is simpler than other payment systems. This suggests that it might be possible to achieve lower total costs in the accounting system of exchange than in other payment systems.

The foregoing analysis has dealt with the costs related to three 'theoretical' payment systems. Actual payment systems tend to be mixed systems comprising features of all the theoretical systems described above. For example, Finland has a fiat money system in which features of the accounting system of exchange have been accentuated with the development of data processing technology. It is not easy to make cost comparisons between the present system and the pure accounting system of exchange because the information necessary for that purpose is not available in all respects. Several payment instruments are used in Finland, information on which is needed for assessing unit costs and frequency of use. In addition, only informed guesses can be put forward concerning the costs of an alternative giro centre. In the following, the problems involved in cost comparisons are discussed in more detail.

6   Costs of the Finnish Payment System

In Finland, payment transactions can be roughly divided into two, partly interlinked, sectors: the transactions of banks and those of the retail trade. In the banking sector, about 87 per cent (in 1985) of all transactions are effected via bank or postal giro. In retailing, cash is the dominant means of payment, about 90 per cent of payments being effected in cash. The banking sector's internal transfers are largely automated and, as a system, they resemble the accounting system of exchange. By contrast, transactions in retailing take place through the fiat money system. To assess the costs of the payment system operating in Finland, information is needed on the use of each means of payment and the various cost items connected with the different chains of transactions. Chart 3 shows the cost flow diagram of a cash transaction.

CHART 3.   COST FLOW DIAGRAM OF A CASH TRANSACTION

```
┌─────────────────────────┐        ┌─────────────────────────┐
│ BUYER'S BANK            │        │ SELLER'S BANK           │
│  - overhead costs of    │        │  - costs of entry of    │
│    withdrawing cash     │        │    cash transaction     │
│  - security costs of    │        │  - costs of handling    │
│    holding money        │        │    money                │
│                         │        │  - security costs of    │
│                         │        │    holding money        │
│                         │        │                         │
└───────────┬─────────────┘        └──────────────┬──────────┘
            │ withdrawal of cash                  │ deposit of cash
┌───────────┴─────────────┐        ┌──────────────┴──────────┐
│ BUYER                   │        │ SELLER                  │
│  - costs of time consumed│       │  - costs of cash transaction│
│    - in the bank        │        │  - cash desk charges    │
│      in the shop        │        │  - subsequent cash desk work│
│  - security costs of    │ cash   │  - security costs of    │
│    holding money        │payment │    holding money        │
└─────────────────────────┘        └─────────────────────────┘
```
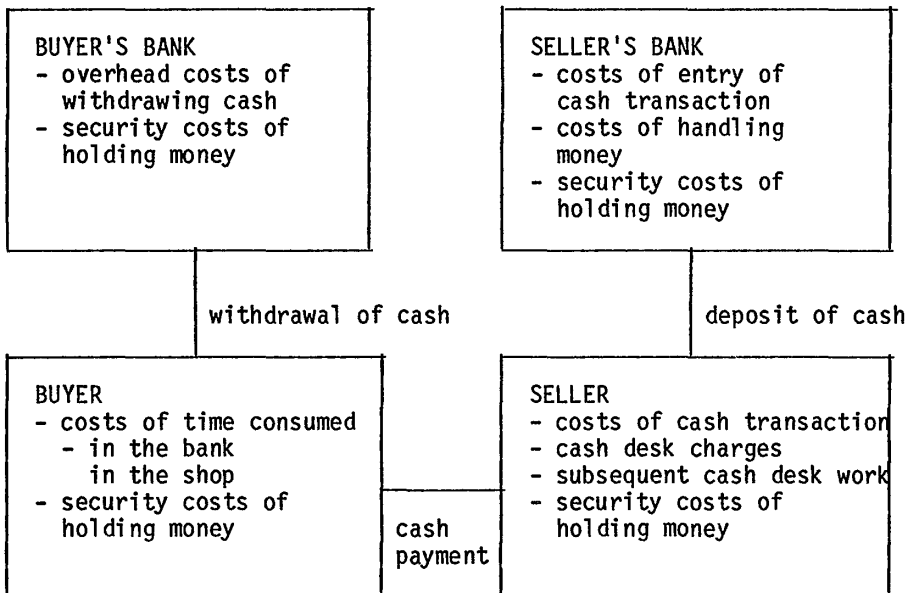
Chart 3 shows that one retail cash transaction involves the circulation of money through the hands of four economic agents. All economic agents incur costs as a result of this transaction. For all

economic agents, the holding of money is a special risk factor, the effect of which on costs depends on the amount of money. For the buyer, the use of cash also involves time-consuming costs, first in the bank in connection with the withdrawal of money and then at the shop when paying in cash. For the seller, cash desk charges and subsequent cash desk work are cost items typical of cash payments.

In Finland, the total costs arising in connection with cash transactions and the use of other means of payment have been estimated in the final and interim reports of the Payment Terminal Project (PTP) published in 1982. The cost calculations in these reports are based on studies of the time consumed in various shops and banks. These estimates do not take into account the costs shown in Chart 3 which the buyer incurs s as a result of consuming time and in connection with the security risks of holding cash. The reports estimate that the total cost of a cash transaction comprises the following components (in terms of ratios):

```
Total cost                                = 1.00
- withdrawal and deposit of cash, total     0.30
- cash payment                               0.40
- overhead cash desk costs                   0.30
```

The total costs of using other means of payment in relation to cash were estimated in the PTP as follows:

```
Cash                               1.00
Passbook                           1.20
Cheque                             1.80
Debit card                         1.87
Credit card (own)                  2.18
Credit card (OK, VISA)             3.65  }  2.92
```

Thus, according to the situation as of 1981, cash was the cheapest payment method in Finland in terms of total costs and credit cards the most expensive. With ongoing technological progress in cashless means of payment, the total costs of these payment instruments in relation to cash can be expected to decline.

In order to assess the total costs associated with the functioning of
the payment system, information is needed on both the volumes of
different means of payment used and the unit costs related to their
use. In retailing, some 1 500 million purchases are made annually, of
which 500 million take place in grocery stores and 1 000 million in
speciality shops and department stores (see Kettunen (1986)). No
precise information is available on the distribution of transactions
between different means of payment in the retail trade as a whole.
Reliable information is available on the distribution of the use of
means of payment in the groceries trade but only estimates can be
presented for trade in department stores and speciality shops
(Kettunen (1986)). Table 5 attempts to estimate the use of different
means of payment in the Finnish retail trade. The estimate is based on
figures compiled by the Finnish Bankers' Association (1986) for volumes
of payments effected by cheque and debit cards through deposit banks
in 1985 and on estimates of the use of means of payment in the retail
trade published by the Central Committee of Commerce (see Kettunen (1986)).

TABLE 5.   ESTIMATE OF THE USE OF DIFFERENT MEANS OF PAYMENT IN
           THE FINNISH RETAIL TRADE IN 1985

Payment method	Share of total payments, %	Number of purchases, millions
Cash	89	1 333
Cheque[1]	4	64
Passbook	3	50
Debit card[1]	2	23
Credit card	2	30
Total	100	1 500

[1] See the Finnish Bankers' Association (1986)

According to Table 5, almost 90 per cent of all payments in the retail
trade are effected in cash. By combining the figures for Table 5 with
the total costs of using different means of payment calculated in the
PTP, it is possible to estimate the total costs incurred by the
economy in connection with transactions in the retail trade. Table 6
shows the total costs to the economy arising from payment transactions
in the retail trade calculated on the basis of different assumptions
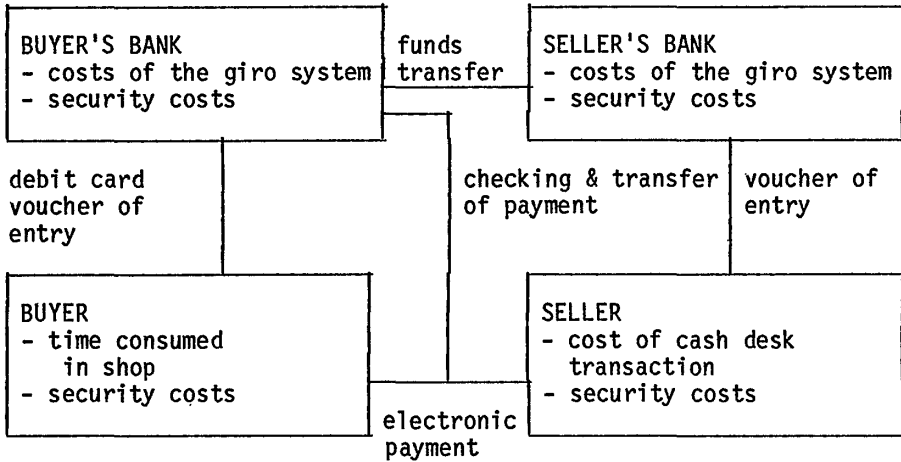on unit costs of a cash transaction.

TABLE 6.   ESTIMATE OF THE TOTAL COSTS TO THE ECONOMY
OF TRANSACTIONS IN THE RETAIL TRADE

Unit cost of cash transaction, FIM	Total costs of retail trade, billion FIM
2	3.3
4	6.6
6	9.8

According to Table 6, the FIM 2 - 6 variation in the unit costs of
cash transactions means a variation of FIM 3 - 10 billion in the total
costs to the economy of retail transactions. These estimates do not
include all the costs pertaining to the maintenance of the payment
system in Finland, because, for example, the banking sector's giro
transfers have been excluded for the sake of simplification. In 1985,
430 million giro transfers were transmitted through deposit banks (The
Finnish Bankers' Association (1986)).

With the development of new technology, the search has begun in the
international markets for payment instruments for payment methods
which are more efficient than cash payments. In a number of countries,
experiments have been carried out with the EFT POS system (Electronic
Funds Transfer at the Point of Sale), whereby payments are effected as
an electronic funds transfer from the buyer's account to the seller's
account through a terminal using the buyer's debit card. This method
eliminates many of the cost items connected with the use of money,
though certain additional costs arise in using the giro system. Chart 4
shows the cost flow diagram of an electronic funds transfer.

CHART 4.   COST FLOW DIAGRAM OF AN ELECTRONIC FUNDS TRANSFER

BUYER'S BANK - costs of the giro system - security costs	funds transfer	SELLER'S BANK - costs of the giro system - security costs
debit card voucher of entry	checking & transfer of payment	voucher of entry
BUYER - time consumed in shop - security costs	electronic payment	SELLER - cost of cash desk transaction - security costs

Security risks are also a significant cost item in the funds transfer system. These costs may prove high for banks, in particular. On the other hand, for the buyer and the seller, electronic funds transfer appears to be a more secure payment method, so long as the bank manages to protect the accounts in a reliable way. Moreover, all the cost items associated with the handling of cash are eliminated when transactions are transmitted by means of electronic funds transfer. For the buyer, visits to the bank are no longer necessary while for the seller, cash desk charges and related cash desk work are eliminated. In the case of banks, staff handling cash transactions can be transferred to other duties. According to Chart 4, it would seem that electronic funds transfers might be a cheaper alternative than cash transactions. For instance, the withdrawal of cash from the buyer's account and the corresponding deposit in the seller's account are effected simultaneously by means of the electronic funds transfer system whereas two separate operations are necessary in the case of a cash transaction. If it is assumed that an electronic funds transfer accounts for half of the cost items related to the withdrawal and deposit of cash in the case of a cash transaction, with other cost items remaining unchanged, the unit cost of an electronic funds transfer amounts to 85 per cent of the corresponding costs of a cash

transaction. Table 7 shows, in terms of the unit costs of different cash transactions, the cost savings to the economy which would be obtained if all retail payments were effected in the form of electronic funds transfers instead of using the means of payment shown in Table 5.

TABLE 7.   ESTIMATE OF THE COST SAVINGS OBTAINED BY INTRODUCING
            THE ELECTRONIC FUNDS TRANSFER SYSTEM IN RETAIL TRADE

Unit cost of a cash transaction, FIM	Annual cost savings obtained with the electronic funds transfer system, billion FIM
2	0.7
4	1.5
6	2.2

It can be seem from Table 7 that, if the unit costs of a cash transaction vary between FIM 2 and 6, the introduction of an electronic funds transfer system could mean annual cost savings totalling FIM 0.7 - 2.2 billion to the economy. This estimate is based on the assumption that the transmission of a payment by electronic funds transfer uses up half the resources required for withdrawing and depositing cash. The savings in the buyer's time allowed by electronic funds transfer have not been taken into account in this estimate. It is difficult to make precise cost comparisons between the present payment system and a potential electronic funds transfer system, because sufficiently reliable information is not available on the cost items in the chains of transactions. Even a minor error in one cost item could mean hundreds of millions of markkas in the final comparison. Depending on different calculation bases, such comparisons can easily lead to great cost differences. Nevertheless, recent developments in the field of payment instruments suggest that the cost benefits of electronic funds transfer have been perceived in the market, and it can be expected that its role will increase in the near future.

II   THE DEMAND FOR MEANS OF PAYMENT

1   Introduction

In traditional monetary theory, three different motives for desiring to
hold means of payment - the transactions, speculative and precautionary
motives - are accorded a central role in seeking to understand the
behaviour of economic agents. The transactions motive for holding
means of payment arises from the fact that means of payment are needed
for effecting transfers of wealth required by business transactions.
The speculative motive for holding means of payment arises from the
fact that means of payment are also forms of wealth. Risk-averse
economic agents endeavour to choose their forms of wealth holdings so
that their return and risk objectives are balanced in an optimal way.
The precautionary motive for holding means of payment arises out of
the desire of economic agents to be prepared for unexpected payment
situations.

These three basic motives provide a general explanation of the reasons
why economic agents hold means of payment. In addition, the demand for
means of payment may be influenced by such factors as imperfections in
financial markets and the special properties of different payment
instruments. Accordingly, a demand model for means of payment which is
as general as possible should, in addition to total holdings of means
of payment, explain the breakdown of means of payment into different
instruments.

In this essay, the demand for money and means of payment is examined
from several perspectives. In Section 2, we consider the demand for
means of payment using three partial models, each of which emphasizes
different motives for holding payment instruments: an extension of the
Baumol-Tobin model emphasizes the transactions motive and differences
in the liquidity of alternative investments, the portfolio model
describes the demand for means of payment from the point of view of
the speculative motive, whereas Lancaster's (1971) 'characteristics'
model emphasizes the role of the qualitative properties of means of
payment in modelling the demand for means of payment. A universally

applicable demand model for money and means of payment should embrace the different explanatory alternatives.

Section 3 examines the demand for means of payment in Finland. Present trends in the use of different payment instruments in Finland are first outlined. This chapter attempts, in particular, to determine how the introduction of new payment instruments (plastic cards) has affected the demand for cash in the 1980s. The demand models for notes and coin are specified according to the theoretical considerations presented above. In particular, it is argued that the demand for different denominations may respond differently to changes in real income, interest rates or the inflation rate and that technological advances in the transmission of payments may have significant demand effects.

2 Basic Principles of Monetary Theory

Means of payment are not normally analyzed separately in economic theory; rather, they are usually dealt with implicitly in monetary theory. Monetary theory, in particular, is concerned with the determination of the supply of and demand for money and the impact of the stock of money on the general price level and other macroeconomic aggregates. The latter area - the macroeconomic effects of monetary theory - provides a close link between monetary theory and general macroeconomic theory and to its sub-divisions dealing with business cycles and the effects of economic policy.

The two key basic assumptions of traditional monetary theory are that the production costs of base money (currency) are zero and that all economic agents accept currency in payment for the surrender of commodities. The first basic assumption implies that the real resource needs of the monetary and payment system and the mutual efficiency of alternative systems are generally abstracted from in monetary analysis. From this assumption it further follows that in traditional monetary theory changes in the quantity of money do not have much effect on the relative prices of commodities in the economy; this particular aspect is dealt with more closely below. The second basic assumption implies

that either money has been assigned the property of legal tender or
that money is, for efficiency reasons, the dominant means of payment.

The simplest basic form of monetary theory is the quantity theory,
which, in its purest form, is based on the assumption that no exchange
of commodities or forms of wealth can be carried out in the economy
without using money for financing transactions. Hence, money has no
alternatives in payment. The implications of the quantity theory are
quite explicit and simple. If there are M units of money in circulation
in the economy during a particular period, if V transactions can be
effected per unit of money during the period (the velocity of
circulation of money is V), if the number of transactions is Q and if
the general price level is notated by P, the following relationship
exists between the variables:

(1) $MV = PQ$

The basic equation of the quantity theory defines the price level P of
the commodity basket representing the exchange in the economy as an
endogenous variable in terms of monetary units (the price of a
monetary unit is 1). The price level obtained is

(2) $P = \dfrac{MV}{Q}$

The equation determining the price level implies that an increase in
the quantity of money or a rise in the velocity of circulation of
money raises the price level, whereas an increase in the number of
transactions lowers it.

In the quantity theory, money acts both as a measure of value and a
means of payment. The price of money in terms of commodities is the
direct inverse of the average price level. Clearly, since, according
to the basic assumption, money does not have a price based on
production costs in terms of commodities, the average price level of
the economy or, conversely, the commodity price of the monetary unit
must be defined by agreement.

In its basic form, the quantity theory represents a somewhat outdated view of the role of the monetary economy in the total economy.[1] Among other things, the theory implies that the stock of money influences the price level and nominal quantities alone, with no effect at all on real quantities. This property could not hold if, for example, the price level or inflation affected the number of transactions. Equation (1) or its derivatives are nevertheless used widely as a technical device for describing money markets in simple macroeconomic models. In particular, the formulation (Clower (1967)) and introduction (e.g. Lucas (1987)) of the cash-in-advance principle have enhanced the role of the quantity theory in business cycle and macroeconomic theories. According to the cash-in-advance principle, at least part of the exchanges in the economy must always be paid for beforehand in cash. The counterpart to equation (1) in accordance with this principle is

(1') $MV \leqslant PQ.$

According to equation (1'), the effective quantity of money can be smaller than the value of transactions, provided that it is not necessary to pay for all commodities in cash in advance.

Another approach which has been applied to derive equations of the demand for money classified as derivatives of the quantity theory is based on the direct utility generated by money to economic agents. In this approach, money is included as an argument in the utility function of the economic agent either directly or, for example, through consumption or production technology.[2]

The fundamental problem of the quantity theory is that it does not take into account the existence of payment methods which are alternatives to money. When an economic agent holds money for effecting payments, he does not receive any nominal interest income for keeping wealth in

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[1]A very recent review of the background, formulation and present state of the quantity theory can be found in Friedman (1986).

[2]See, for example, Sidrauski (1967), Feenstra (1986) and McCallum - Goodfriend (1987).

a liquid form. Indeed, in real terms, he steadily loses wealth if the price level of the economy is rising. The real relative interest expense of money is equal to the rate of inflation. By contrast, means of payment which are alternatives to money frequently yield nominal interest income to the economic agent and hence a higher real return or smaller real losses than is the case with holding money. From the point of view of the quantity theory, this implies that efficiency in the use of money depends on both the nominal rate of interest and the rate of inflation. In terms of modelling and also intuitively this is reflected primarily in the dependence of the velocity of money on the nominal rate of interest. In equation (1) the existence of alternative means of payment can be taken into account by writing it in the form

$$(1'') \quad MV(i) = PQ; \quad \frac{\partial V}{\partial i} > 0$$

$$i = \text{nominal rate of interest}$$

The impact of the interest rate is reflected in the behaviour of economic agents: the higher the rate of interest, the quicker economic agents place their cash receipts in bank accounts and in other interest-earning assets. This implies that the demand for money diminishes as the nominal interest rate rises.

On the other hand, the rate of inflation affects the demand for money through the linkage between inflation and the nominal rate of interest. A fairly common view is that the natural real rate of interest clearing the economy in the longer term is an exogenous variable which cannot be influenced by measures taken by economic agents. It thus follows that the nominal rate of interest is positively related to the sum of the real interest rate and the rate of inflation over a certain period. In a general form and without time dependence, this relationship can be written in the following form:

$$(4) \quad i = f(r + \pi); \quad \frac{\partial f}{\partial (r + \pi)} > 0$$

$$r = \text{real rate of interest}$$

$$\pi = \text{rate of inflation}$$

If the functional form of equation (4) is constant 1 ($i = r + \pi$), the Fisher parity is said to hold in the formation of the nominal interest rate.

The basic equation of the quantity theory, taking into account the existence of other means of payment, can now be written in the following form:

(5) $MV(f(r + \pi)) = PQ$

Equation (5) can be interpreted as an equation for the demand for money, when the nominal interest rate is an exogenous (monetary policy target) variable. According to equation (5), the demand for money (non-interest-bearing means of payment) decreases as the real interest rate or the rate of inflation rises, but increases as the price level or the number of transactions rises. By contrast, if the supply of money serves as the exogenous (monetary policy target) variable, equation (5) determines the price level and - in a dynamic sense - the rate of inflation in the economy.

The overall view of the nature of the demand for money and means of payment provided by the extended version of the quantity theory contains several important interpretations and additional considerations. First, it may be useful to recall that while the behaviour of economic agents in its simplest form can be described technically by relationships similar to equation (5), in monetary theory it is illustrated at the intuitive level in terms of various motives for holding money. Traditionally, the demand for money is seen as being based on the transactions, speculative and precautionary motives.

The transactions motive for holding money (means of payment) derives from the fact that in a monetary economy no business transactions can be effected without using money for the transfers of wealth necessitated thereby. A transaction - and thus, e.g. a purchase of a commodity or service - simply cannot be effected without some means of payment. This implies that economic agents must hold, on average, that quantity of means of payment necessary for effecting their planned business transactions.

The speculative motive for holding money (means of payment) arises from the fact that means of payment are also forms of holding wealth. Viewed from this perspective means of payment differ from, for example, securities or real assets only in the sense that the effective return and risks related to holding them differ from the corresponding characteristics of potential alternative assets. An investor seeking to minimize risks holds a portfolio of all investments so that his profit and risk objectives are balanced in an optimal way.

The precautionary motive for holding money (means of payment) is directly connected with the perfect or almost perfect liquidity of means of payment compared with other assets. The activities of economic agents in a normal economic environment occasionally give rise to unexpected needs for expenditure. These may either be actual unforeseen expenses or exceptionally attractive purchase opportunities requiring rapid response. Under these circumstances, the use of non-money assets may entail substantial costs resulting from their conversion into money. Accordingly, it may pay economic agents to prepare for unexpected situations by holding some quantity of means of payment which they consider necessary.

In the interpretation of the extended version of the quantity theory, the transactions motive points to a positive relationship between the demand for money and the volume of transactions. On the other hand, the speculative motive creates a link between the nominal interest rate and the demand for money. The interpretation of the precautionary motive is not so simple. One way of interpreting it is that the special characteristics of money in dealing with unanticipated payment situations tend to weaken the negative relationship between the demand for money and the interest rate.

Another important issue is the relationship between money and other means of payment. According to the extended version of the quantity theory, this relationship is revealed only through the dependence of the demand for money on the interest rate. In addition, in basic formulations like those in equation (5), the alternatives to money are only represented by one interest rate. Certainly in a more sophisticated

model, one interest rate could be replaced by an interest rate index
or an average interest rate representing a "basket" of several
alternative assets.

In principle, all means of holding wealth (money, securities, stocks
of goods, real estate, real investments, etc.) could be instruments of
wealth transfer and hence perfect alternatives to money. Moreover, it
is likely that all forms of holding wealth are used as means of
payment in some transactions. Nevertheless, it is normally the case
that many components of wealth can be used directly as means of
payment only on very rare occasions. Rather, such assets are used
indirectly in effecting payments. The asset is first converted into
money (usually a means of payment) in its own market; money is then
subsequently used for effecting payments in some other market.

Basically, then, the special role of means of payment in the economy
stems from market imperfections. Since markets are not equally
efficient or perfect with respect to all forms of holding wealth, not
all forms of wealth can be exchanged (used for payment) equally
smoothly. Broadly speaking, there are liquidity differences between
different forms of wealth.

The precise definition and operationalization of the liquidity of
assets is a complex question to which there may not exist any generally
accepted answer. A reasonably extensive and promising measure of the
liquidity of assets has recently been put forward by Lippman & McCall
(1986), (LM). According to their definition, the liquidity of assets
depends on how long it takes before the economic agent can convert the
assets in question into means of payment, when he pursues an optimal
selling policy. The optimal selling period (i.e. liquidity) is affected
by the maintenance, sales and search costs (for example, the interest
rate, commissions and costs of searching bids), the stochastic process
of bids and the economic agent's attitude towards the future (the
magnitude of the discount factor). Of the factors affecting liquidity,
the first and the last are plausible and explicit independent variables.
The stochastic process of bids refers to the sequence of bids arriving
at different points of time. Bids are random, and the seller need not

- or it may not pay him to - accept the first bid. The process of bids can be thought to describe the nature of the asset markets. In a thin market, bids can be thought to arrive rarely and prices can be assumed to vary substantially. By contrast, in a deep market, bids are fairly stable and arrive frequently.

According to the LM definition, means of payment are perfectly liquid forms of holding wealth while other assets are the more liquid the shorter the time it takes to convert them into means of payment in an optimal way. This definition corresponds in many respects to the practical idea of the concept of liquidity - in light of which it is easy to put forward plausible interpretations concerning, for example, the liquidity differences between real estate and bonds.

However, at least two reservations must be attached to the coverage of this definition. The first concerns the fact that, according to the LM definition, the forms of wealth classified as means of payment need not necessarily be equally liquid. For example, not all payment instruments can be used for effecting payments in all situations. Only legal tender has this status in the economy. Hence, the holder of a means of payment other than legal tender may be forced to search for a shop in which the means of payment at his disposal can be used for payment. This entails search costs in the same way as the search for bids.

The second reservation arises from the fact stated above that very illiquid means of wealth in the sense of the LM definition can be used as means of payment in certain cases. For example, in the real estate market, certificates of deposit, securities generally and even real estate can be used as means of payment. This implies that not all transfers of wealth in the economy associated with various business transactions occur by first converting wealth into means of payment which are then transferred to the recipient of payment. Several payment techniques can be thought to exist in the economy. Which technique is used will depend on the particular situation but the most dominant technique is that based on conversion into means of payment.

The notion that all forms of wealth possess some degree of liquidity through the possibility of converting them into cash has led to the

introduction of liquidity indices in empirical research.[3] As a result, empirical equations of the demand for money based on equation (5) do not explain the demand for base money but rather the determination of the demand for some liquidity aggregate. The liquidity aggregate is constructed by weighting together forms of wealth with varying degrees of liquidity using index techniques or some other weighting mechanism.

Finally, it should be noted that even those forms of holding wealth which are so liquid that they are generally regarded as means of payment may differ from each other as regards other characteristics from the point of view of economic agents. The holding or using of a certain means of payment may, for example, entail a greater risk of wealth loss than the holding or using of an alternative means of payment. Furthermore, some means of payment guarantee anonymity in payment while in using others it is absolutely essential to register the chain of payers in the system.

Such differences naturally affect the aggregate demand for means of payment and particularly the distribution of demand between the different payment instruments.

To conclude these remarks on the quantity theory, it can be stated that the three traditional fundamental motives of monetary theory provide a clear overall picture of what factors are of importance in determining the quantity of means of payment. It is nevertheless obvious that none of these motives suffice as such as a general explanation or theory for holding means of payment. A general model should of necessity embrace all three motives simultaneously. Moreover, additional factors might be needed in a general model to take into account, on the one hand, imperfections in financial markets and, on the other hand, the special features of different means of payment. A general model would then not only explain the total quantity of means of payment held but also its distribution between different forms.

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[3]Recent studies in this field include those by Sims – Takayama – Chao and Serletis – Robb (1986).

The following analysis attempts to examine the demand for money taking into account the additional considerations presented above. In this context, it is not possible to develop a general theory or model of the demand for means of payment; rather, the analysis is carried out using three partial models. The demand for means of payment is first dealt with by applying the Baumol-Tobin model, then within the framework of portfolio theory and finally in Lancaster's characteristics model.

2.1 The Baumol-Tobin Model

The Baumol-Tobin (BT) model[4] provides a simplified but at the same time robust approach to the demand for money emphasizing the transactions motive and the liquidity differences between various assets. In the simplest basic form of the BT model, an economic agent receives real income y at the beginning of each period. In the course of the period, he makes payments in a steady stream, so that his total income is used up in full by the end of the period, the economic agent may either hold it in the form of cash or invest it in securities bearing interest at rate r. Payments can only be effected in cash and the conversion of securities into cash involves transactions costs amounting to γ units per conversion. Since the problem is essentially a symmetric one, it can be assumed that the economic agent is able to convert securities into cash at regular intervals and in equal amounts in the course of the period. Let one conversion be equal to B. Given the steady stream of payments, the average amount of money held by an economic agent is thus 1/2 B. The interest income lost by holding cash is $C_r = 1/2\ rB$. The conversion of securities into cash takes place y/B times over the entire period, so that transactions costs amount to $C_T = \gamma y/B$. The

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economic agent seeks to minimize his total costs $C = C_r + C_T$. Hence, his decision problem can be expressed in the following form:

(6) $\min\limits_{(B)} \left(\frac{1}{2} rB + \gamma \frac{y}{B}\right)$

The optimal size of the lot of securities converted into cash implied by the problem is

(7) $B = (2\gamma)^{\frac{1}{2}} y^{\frac{1}{2}} r^{-\frac{1}{2}}$

It was stated above that, on average, the economic agent's real cash holdings, i.e. real means of payment, are equivalent to half the optimal size of the amount converted. Thus

(8) $\frac{M}{P} = \frac{1}{2} (2\gamma)^{\frac{1}{2}} y^{\frac{1}{2}} r^{-\frac{1}{2}}$

The nominal quantity of means of payment held by the economic agent can then be expressed in logarithmic form as follows:

(9) $\log M = \log \frac{1}{2} + \frac{1}{2} \log 2 + \frac{1}{2} \log \gamma + \frac{1}{2} \log y + \log P - \frac{1}{2} \log r$

According to the equation, a one per cent rise in transactions costs or real income leads to 0.5 per cent increase in money holdings. A corresponding rise in the price level increases the demand for money by one per cent. By contrast, a one percentage point (exactly one per cent) rise in interest receipts on securities diminishes the demand for money by 0.5 per cent.

Thus, in its basic form, the Baumol - Tobin model incorporates four factors as independent variables in the demand for money: the real income level, transactions costs and the price level exert a positive effect and the interest rate level a negative effect on the demand for money. The relationships between the independent and dependent

variables are precisely defined and easy to interpret. According to
the model, the holding of money involves economies of scale. The
greater the volume of economic activity (real income), the smaller is
the ratio of real cash holdings to the level of activity.

In the following the Baumol - Tobin model is extended so that another
payment technique and another means of payment can be incorporated.
The extension could be carried out in several different ways, for
example, by including factors emphasizing portfolio and precautionary
motives in the model. However, in the present context, we endeavour to
adhere closely to the tradition of the Baumol - Tobin model, according
to which the holding of means of payment is determined by their
transactions properties.

Thus, it is assumed that the assumptions concerning the economic
agent's income and payment flows, investment opportunities and method
of payment based on the use of money are exactly the same as in the
basic model. However, the economic agent can effect payments using
either money or a credit card. The economic agent pays interest on his
average credit card credit at a rate of r_L, which may differ from the
rate of interest r in the securities market because of taxation reasons
or money market imperfections. Let us assume that $1-\lambda$ per cent of the
companies (or payment points in general) with which the economic agent
transacts business, are members of the credit card system. The
economic unit can effect the payments owing to these outlets directly
to the card company on the due date in the form of securities without
transactions costs. However, λ per cent of the payment points are not
members of the card system. The economic agent may also pay by card in
these payment points, but then a fixed invoicing charge of γ_L markkas
per invoice is included in the invoice. For the sake of simplicity, it
is assumed that the economic agent does not know in advance in which
payment point's transactions include an invoicing charge. Rather, he
considers the percentage share λ to be the objective probability of an
additional charge arising.

In the decision-making environment described above, the economic agent
decides which proportion (ξ) of his payments he pays in money and

which proportion $(1-\xi)$ by credit card, how many times (n_1) and in how large lots (B) bonds are converted into money, and how large, on average, is his outstanding credit (implying, inter alia, the optimal choice of invoicing times (n_2) - i.e. the invoicing interval - and size (b) of invoice). In order to simplify the analysis, it is assumed that the economic agent takes a risk-neutral attitude towards the uncertainty related to the invoicing charge. The economic agent's decision-making problem reduces to minimizing expected interest and transactions costs. On the basis of the foregoing information, the expected value of the economic agent's cost function is as follows:

(10) $\quad E(C) = \frac{1}{2} rB + \frac{1}{2} r_L b + \gamma n_1 + \lambda \gamma_L n_2$

Compared with the basic model, the cost function now includes a term for the interest expense of card credit $\frac{1}{2} r_L b$ and a term describing the expected invoicing cost $\lambda \gamma_L n_2$.

As all payments in the economy are effected using either of the two payment techniques, the following equation must also hold for an individual economic agent:

$n_1 B + n_2 b = y$

Payment shares ξ and $1-\xi$ are now defined as follows:

$\xi \equiv \dfrac{n_1 B}{y}$

$1-\xi \equiv \dfrac{n_2 b}{y}$

Thus, the economic agent's cost minimization problem can now be written in the following form:

(11) $\min \left\{ \frac{1}{2} \left[\dfrac{\xi}{n_1} + \dfrac{(1-\xi)}{n_2} r_L \right] y + \gamma n_1 + \lambda \gamma_L n_2 \right\}$

$\quad \{\xi, n_1, n_2\}$

It can be shown that the resulting average real demand for money (M/P) and the amount of credit (L/P) in this model are:

$$(12) \quad \frac{M}{P} \equiv \frac{1}{2} B = \frac{1}{2}^{\frac{1}{2}} (r\gamma + r_L \lambda\gamma_L)^{-\frac{1}{2}} \gamma y^{\frac{1}{2}}$$

$$(13) \quad \frac{L}{P} \equiv \frac{1}{2} b = \frac{1}{2}^{\frac{1}{2}} (r\gamma + r_L \lambda\gamma_L)^{-\frac{1}{2}} \lambda\gamma_L y^{\frac{1}{2}}$$

Furthermore, the shares of the alternative methods of payments are as follows:

$$(14) \quad \xi = \frac{r\gamma}{r\gamma + r_L \lambda\gamma_L}$$

$$(15) \quad 1-\xi = \frac{r_L \lambda\gamma_L}{r\gamma + r_L \lambda\gamma_L}$$

It is easiest to compare the model with the basic model by writing the demand equations for the means of payment in terms of logarithms, i.e.

$$\log M = \frac{1}{2} \log \frac{1}{2} - \frac{1}{2} \log (r\gamma + r_L \lambda\gamma_L) + \log \gamma + \frac{1}{2} \log y + \log P$$

$$\log L = \frac{1}{2} \log \frac{1}{2} - \frac{1}{2} \log (r\gamma + r_L \lambda\gamma_L) + \log \lambda\gamma_L + \frac{1}{2} \log y + \log P$$

It is easy to conclude from the demand equation for money that only the price elasticity of money demand (= 1) and the real income elasticity (= 1/2) remain unchanged compared with the basic model. As might be expected the interest rate elasticity of money demand has decreased $(-\frac{1}{2} \rightarrow -\frac{1}{2}\xi)$ and the transactions cost elasticity $(\frac{1}{2} \rightarrow 1 - \frac{1}{2} \xi)$ increased. Money is a substitute for credit card overdraft (substitution elasticities with respect to both r_L and $\lambda\gamma_L$ equal to $-\frac{1}{2} (1-\xi)$).

In a model of the Baumol-Tobin type, the correlation between the demand for money and its parameters can easily be generalized to a case in

which there are n alternative means of payment. If the proportion of transactions effected in money is generally ξ_1, the corresponding general interest rate elasticity of money demand is $-\frac{1}{2}\xi_1$ and the transactions cost elasticity $1 - \frac{1}{2}\xi_1$. It follows from the symmetry of the structure of the Baumol-Tobin model that the interest rate elasticity of an arbitrary means of payment i (proportion of transactions = ξ_i) with respect to its own rate of interest r_i is $-\frac{1}{2}\xi_i$ and the transactions cost elasticity $1 - \frac{1}{2}\xi_i$. The extended Baumol-Tobin model thus has two general properties: an increase in the number of alternative means of payment in the economy results, on the one hand, in a fall in the interest rate elasticities of the demand for means of payment and, on the other hand, in an increase in their transactions cost elasticities. The former effect can be interpreted to mean that the interest rate elasticity of the demand for each means of payment reflects its substitutability between liquidity and other types of wealth. If capital markets function efficiently so that the shadow interest rates for each means of payment vary similarly, the "total substitution" between various means of payment and other forms of wealth is independent of the interest rate level. For this to be valid the introduction of a new means of payment must reduce the interest rate elasticities of other means of payment. The second property derives from the fact that transactions costs represent the relative prices of alternative means of payment in the extended Baumol - Tobin model. By applying the analogy from the diversified products model, the introduction of a new means of payment implies a decline in product differences in the market for means of payment. The greater the number of alternative means of payment there are in a market of given size, the closer substitutes they are for each other.

Finally, it is worth noting that the extended Baumol-Tobin model can also be applied to the analysis of factors affecting the demand for qualitative means of payment which can be presented in the form of penalty costs corresponding to transactions costs. This application is dealt with briefly in Chapter 2.3.

2.2 Portfolio Model

The most obvious way to analyze the demand for means of payment from
the point of view of the speculative motive is in the context of a
portfolio-theoretic model. Even in the case of the simplest models,
this requires the inclusion of uncertainty in the analysis and the
specification of economic agents' attitudes towards uncertainty.
Without these factors, there would not generally be any demand at all
for money in a portfolio model, because usually the effective average
return on other forms of wealth exceeds the return on money. Other
forms of wealth would then be dominant assets with respect to money.

In the following analysis, the demand for money is dealt with in the
case of three different portfolio models. After presenting the basic
model, the model is extended by including factors depicting liquidity
differences (practicability as a means of payment) between assets,
which makes it possible to incorporate certain features typical of the
transactions motive in the speculative motive for holding means of
payment.[5]

2.2.1 The Basic Framework

We start by developing a simple dynamic portfolio model, which is the
basic framework of a representative consumer à la Merton (1971, 1973).
To make the properties of the model comparable with the Baumol-Tobin
we assume a situation in which there are two alternative investments
and the consumption decisions are ascribed a secondary role. Thus it
is assumed that the wealth constraint of a representative
consumer-investor, expressed in flows, is of the following form:

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[5]The model frameworks are based on a dynamic portfolio model first
presented by Merton (1971, 1973) and further developed by, among
others, Breeden (1979) and Cox - Ingersoll - Ross (1985).

$$(16) \quad dW(t) = \frac{dP_m(t)}{P_m(t)} P_m(t) M(t) + \frac{dP_B(t)}{P_B(t)} P_B(t) B(t) - cdt$$

where

W(t)   = wealth at time t

M(t)   = stock of money at time t

$P_m(t)$ = price of money at time t

B(t)   = quantity of securities at time t

$P_B(t)$ = price of securities at time t

cdt   = consumption flow

Given the definitions

$$\xi \equiv \frac{P_m(t) M(t)}{W(t)}$$

and

$$1-\xi \equiv \frac{P_B(t) B(t)}{W(t)},$$

the wealth constraint is obtained in the form

$$(17) \quad dW(t) = \xi \frac{dP_m(t)}{P_m(t)} W(t) + (1-\xi) \frac{dP_B(t)}{P_B(t)} W(t) - cdt$$

It is assumed that the prices of money and the alternative asset follow Ito processes as follows:

$$dP_m(t) = r_m P_m(t) \, dt + \sigma_m P_m(t) \, dZ_m$$

$$dP_B(t) = r_B P_B(t) \, dt + \sigma_B P_B(t) \, dZ_B$$

$$dZ_j \sim N(0,dt) \ \text{i.i.d.} \ ; \ j = m, B$$

Thus returns on investment alternatives are normally distributed random variables for each interval (t, t + dt). If in addition, it is assumed that the instantaneous utility function of the consumer-investor is

u(c) and that he has an infinite planning horizon, his decision-making problem can be described by means of the following Hamilton - Jacobi - Bellman (HJB) equation:

$$(18) \quad 0 = \max \{ u(c) - \rho J + J_W [(\xi r_m + (1-\xi)r_B)W - c]$$

$$+ \frac{1}{2} J_{WW} \left[\xi^2 \sigma_m^2 + (1-\xi)^2 \sigma_B^2 + 2\xi(1-\xi)\sigma_{mB} \right] W^2 \}$$

J(W) = intertemporal maximum value function

$$J_W = \frac{\partial J(W)}{\partial W}$$

$$J_{WW} = \frac{\partial^2 J(W)}{\partial W^2}$$

$$J_t = \frac{\partial J(W)}{\partial t}$$

Solutions to the optimal consumption flow and the optimal portfolio proportions can be derived from the HJB equation. The latter are of the form:

$$(19a) \quad \frac{P_m M}{W} \equiv \xi = \frac{\sigma_B^2 - \sigma_{mB}}{\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB}} - \frac{J_W}{J_{WW}W} \cdot \frac{(r_m - r_B)}{(\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB})} \equiv \xi^m + \xi^s$$

$$(19b) \quad \frac{P_B B}{W} \equiv 1-\xi \equiv 1-\xi^m-\xi^s$$

$$\xi^m = \frac{\sigma_B^2 - \sigma_{mB}}{\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB}} = \text{the minimum variance portfolio share}$$

$$\xi^s = - \frac{J_W}{J_{WW}W} \cdot \frac{(r_m - r_B)}{(\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB})} = \text{the speculative portfolio share}$$

Thus optimal portfolios of the consumer-investor consist of two components. The minimum variance portfolio is determined merely through the risks inherent in the returns on money and securities. The speculative portfolio is affected by both expected returns, risks and the economic agents's attitudes towards risk (the multiplier $-\dfrac{J_{WW}W}{J_W}$ is the Arrow-Pratt measure of the relative degree of risk-aversion).

A closer interpretation of portfolio proportions calls for the restriction of the parameter values of the model. As some kind of a conventional case, one can consider a situation in which money is a less risky asset than securities ($\sigma_B^2 > \sigma_m^2$; $\sigma_B^2 > \sigma_{mB}$), but yields a smaller average return ($r_B > r_m$) and in which the investor is risk-averse ($-\dfrac{J_W}{J_{WW}W} > 0$). In that case, the proportions of both money and securities are positive in the minimum variance portfolio (and the proportion of money is greater). By contrast, the speculative investment proportion of money is negative, whereas the corresponding share of securities is positive (= the opposite of the investment share of money).

2.2.2   The Basic Model and Transactions Costs

In the basic model, the demand for money and an alternative means of payment depends merely on their respective returns and risks and on the investor's attitudes towards risk. Among other things, differences in the transactions costs of alternative investments are ignored completely. Since, in the case of non-interestbearing money, the real rate of return on money is the opposite of the inflation rate - thus usually a negative figure - there may, because of this shortcoming, arise situations in the basic model in which the investor desires to hold a negative quantity of money. This is not a realistic outcome at least whenever money refers to legal tender which is the only fully liquid means of payment in the economy.

It is difficult to take into account transactions costs differing from zero in the dynamic portfolio model. However, it may be possible with the aid of the following simple partial analyses to illustrate what

kind of effects transactions costs might exert in general models. It is assumed in the analyses that transactions costs are proportional to the consumption flow and that consumption and portfolio decisions are separate from each other, so that the consumption flow can be dealt with exogenously when deciding upon the allocation of portfolio.

It is first assumed that transactions costs are certain, so that when the consumer pays for his consumption flow in money or bonds, he incurs certain costs of a_m or a_B ($a_B > a_m$) units for the transactions. The consumer's instantaneous transactions cost function c^τ then takes the following form:

$$c^\tau = [\xi a_m + (1-\xi)a_B]cdt$$

If the instantaneous transactions cost function is incorporated properly into the decision-making problem of the consumer-investor and the HJB equation pertaining to the extended problem is formulated, the following solution is obtained for the portfolio problem of the consumer-investor (it is assumed here that the consumption-saving behaviour is such that a solution exists):

$$(20) \quad \xi = \frac{\sigma_B^2 - \sigma_{mB}}{\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB}} - \frac{J_W}{J_{WW}W} \frac{\left[(r_m - r_B) + (a_B - a_m) \frac{c}{W} \right]}{(\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB})}$$

$$\equiv \xi^m + \xi^s + \xi^\tau$$

$$\xi^\tau = - \frac{J_W}{J_{WW}W} \left[\frac{(a_B - a_m) \frac{c}{W}}{\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB}} \right]$$

The inclusion of proportional riskless transactions costs in the model changes the behaviour of the consumer-investor so that he constructs a hedging portfolio $[\xi^\tau, -\xi^\tau]$ to neutralize the effects of transactions costs. The hedging portfolio is essentially a speculative portfolio: in the case of two alternatives, the portfolio proportions are the opposites of each other, and hedging does not tie up capital in net

terms. If, as was assumed above, $a_m < a_B$, the proportion of money in the hedging portfolio is positive and, respectively, the proportion of bonds negative.

Next, it is assumed that proportional transactions costs involve uncertainties, so that the temporary transactions cost function of a representative economic agent is as follows

$$c^T = [\xi(a_m dt + \sigma_1 dz_1) + (1-\xi)(a_B dt + \sigma_2 dz_2)]c$$

$$dz_1 \sim N(0, dt) \qquad \text{i.i.d.}$$

$$dz_2 \sim N(0, dt) \qquad \text{i.i.d.}$$

$$cov(dz_1, dz_2) = \rho_{12}\sigma_1\sigma_2 dt \equiv \sigma_{12} dt$$

$$cov(dz_i, dz_j) = 0 \quad ; i = m, B$$
$$j = 1, 2$$

Thus, transactions costs vary normally around their trend path and are not, according to the assumption, correlated with the returns on alternative assets.

In this context, we do not pay closer attention to the fact that, according to the assumption, transactions costs could be negative with a positive probability. When the transactions cost function is duly taken into account in the decision-making of the consumer-investor, the HJB equation illustrating the choice problem obtains the following form:

$$(21) \quad 0 = max\{u(c) - \rho J + J_W[(\xi(r_m - r_B) + r_B)W - (\xi(a_m - a_B)$$

$$- a_B)c] + \frac{1}{2} J_{WW}[(\xi^2\sigma_m^2 + (1 - 2\xi + \xi^2)\sigma_B^2 + 2(\xi - \xi^2)\sigma_{mB})W^2$$

$$+ (\xi^2\sigma_1^2 + (1 - 2\xi + \xi^2)\sigma_2^2 + 2(\xi - \xi^2)\sigma_{12})c^2]\}$$

The consumer-investor's optimal portfolio policy, which is obtained by solving the first order conditions of the HJB equation is of the following form

$$(22) \;\; \xi = \frac{(\sigma_B^2 - \sigma_{mB})W^2}{(\sigma_T^2 W^2 + \sigma_c^2 c^2)} + \frac{(\sigma_2^2 - \sigma_{12})c^2}{(\sigma_T^2 W^2 + \sigma_c^2 c^2)} - \frac{J_W((r_m - r_B)W + (a_B - a_m)c)}{J_{WW}(\sigma_T^2 W^2 + \sigma_2^2 c^2)}$$

$$\equiv \tilde{\xi}^m + \tilde{\xi}^s + \xi_1^\tau + \xi_2^\tau$$

where

$$\sigma_T^2 = \sigma_m^2 + \sigma_B^2 - 2\sigma_{MB}$$

$$\sigma_c^2 = \sigma_1^2 + \sigma_2^2 - 2\sigma_{12}$$

$$\tilde{\xi}^m = \frac{(\sigma_B^2 - \sigma_{mB})W^2}{(\sigma_T^2 W^2 + \sigma_c^2 c^2)}$$

$$\tilde{\xi}^s = \frac{J_W(r_m - r_B)W}{J_{WW}(\sigma_T^2 W^2 + \sigma_c^2 c^2)}$$

$$\xi_1^\tau = \frac{(\sigma_2^2 - \sigma_{12})c^2}{(\sigma_T^2 W^2 + \sigma_c^2 c^2)}$$

$$\xi_2^\tau = -\frac{J_W(a_B - a_m)c}{J_{WW}(\sigma_T^2 W^2 + \sigma_c^2 c^2)}$$

Thus, in the case of proportional transactions costs, involving risk, the portfolio proportions consist of four different components. The interpretation of the partial portfolios is simplified if it is assumed that the ratio of consumption to wealth is a constant independent of the level of wealth. Let the consumption rule of the consumer-investor be of the following form:

$$C = AW \qquad\qquad ; A > 0$$

The solutions for the sub-portfolios can then be written as follows:

$$\tilde{\xi}^m = \frac{\sigma_B^2 - \sigma_{mB}}{\sigma_T^2 + A^2\sigma_C^2}$$

$$\tilde{\xi}^s = \frac{J_W(r_m - r_B)}{J_{WW}(\sigma_T^2 + A^2\sigma_C^2)W}$$

$$\xi_1^\tau = \frac{(\sigma_2^2 - \sigma_{12})A^2}{\sigma_T^2 + A^2\sigma_C^2}$$

$$\xi_2^\tau = - \frac{J_W(a_B - a_m)A}{J_{WW}(\sigma_T^2 + A^2\sigma_C^2)W}$$

The partial portfolio $\tilde{\xi}^m$ corresponds to the minimum variance portfolio of the basic model, but the proportion of money defined by it is smaller than the portfolio proportion ξ^m because the denominator of the latter expression is smaller than that of the former. Furthermore, the proportion $\tilde{\xi}^s$ corresponds to the speculative portfolio proportion ξ^s , but, for the above reason, it is smaller in absolute terms. The partial portfolio ξ_1^τ is the minimum variance portfolio arising from the need to hedge against temporary transactions costs: portfolios $\tilde{\xi}^m$ and ξ_1^τ together determine the minimum variance portfolio of the extended problem the sum of whose fractions is one. Fraction ξ_2^τ is a speculative hedging portfolio, which the investor forms in order to hedge himself against transactions costs. The total of both the speculative portfolios ($\tilde{\xi}^s$ and ξ_2^τ) is zero.

In the case of uncertain proportional transactions costs, it is noteworthy that the interest rate sensitivity of the demand for money is lower than in the case of certain transactions costs. Uncertainty about transactions costs increases the risks of holding wealth in general and hence diminishes the size of the original speculative portfolio dependent on expected returns. This directly implies a fall

in the interest rate sensitivity of demand. By contrast, the impact of
the increase in uncertainty in transactions costs on the portfolio
fractions is unclear: the proportion of money in the porfolio may
either grow or diminish as the total variance of transactions costs
grows, depending on the size of standard deviations and the value of
the correlation coefficient. Compared with the case of riskless
transactions costs, the risk in these costs increases the portfolio
proportion of money, if the average transactions cost of money exceeds
the average cost of an alternative asset by "a sufficient amount"
($a_B - a_m < -R_c$) or if the standard deviation of the transactions costs
of money is "sufficiently small" ($\sigma_2^2 - \rho_{12}\sigma_1\sigma_2 < R_s$) or if the total
impact of both factors is sufficiently strong. In the conditional
expressions, R_c and R_s are positive constants dependent on exogenous
factors and they determine the critical limits within which the
portfolio proportion of money under riskless transactions costs
is smaller than in the case of transactions costs involving risk.

2.2.3 The Basic Model and Security Risk

Finally, a qualitative property connected with the use of means of
payment is examined within the framework of the portfolio model. The
analysis illustrates the effects which other combarable or similarly
functioning factors may have in portfolio models. It is assumed that
alternative portfolio assets are associated with the probabilities
$\lambda_i dt$ (i = m, B) that wealth of type i will be totally lost because of
the occurrence (e.g. because of disappearance or criminal operations)
of security risk. In that case, the returns on alternative assets can
be shown to follow combined Ito-Poisson processes, and the HJB equation
describing the decision-making problem of the consumer-investor can be
written as follows:

(23) $0 = \max\{u(c) - \rho J_t + J_W[(\xi(r_m - r_B) + r_B)W - c]$

$+ \frac{1}{2} J_{WW}[\xi^2\sigma_m^2 + \sigma_B^2 - 2\sigma_{mB}) - 2\xi(\sigma_B^2 - \sigma_{mB}) + \sigma_B^2]W^2$

$+ \lambda_m[J((1 - \xi)W) - J(W)] + \lambda_B[J(\xi W) - J(W)]\}$

In this particular case, it is very difficult to solve the consumer-investor's problem. Solving both consumption and portfolio policies would require an explicit definition of the agent's preferences. Even if the precise form of preferences were known, the solution of the portfolio policy would be of a highly complex form and not necessarily explicit. However, the nature of the solution is illustrated by the following implicit form, which can be used to express the portfolio rule (for the solution to a model of this type, see Honkapohja - Lempinen (1987)):

$$(24) \quad \xi = \frac{\sigma_B^2 - \sigma_{mB}}{\sigma_T^2} - \frac{J_W}{J_{WW} W \sigma_T^2} (r_m - r_B) + \frac{J_W^m}{J_{WW} W^2 \sigma_T^2} \lambda_m$$

$$- \frac{J_W^B}{J_{WW} W^2 \sigma_T^2} \lambda_B \equiv \xi^m + \xi^s + \xi_\lambda^m + \xi_\lambda^B$$

$$J_W^m = J_W(\xi W = 0)$$

$$J_W^B = J_W((1 - \xi)W = 0)$$

$$\xi_\lambda^m = \frac{J_W^m}{J_{WW} W^2 \sigma_T^2} \lambda_m$$

$$\xi_\lambda^B = - \frac{J_W^B}{J_{WW} W^2 \sigma_T^2} \lambda_B$$

According to the implicit solution, the portfolio proportion of money consists of the fractions of the minimum variance portfolio and the speculative portfolio and of the fractions of two new speculative portfolios. The speculative portfolios ξ_λ^m and ξ_λ^B help the investor to hedge himself against the risks of losing wealth inherent in holding two means of payment. The portfolio proportion ξ_λ^μ is, of course, negative, since it describes hedging against the risk of losing wealth in the form of money. By contrast, the proportion ξ_λ^B is positive. The net impact of the two proportions can hence be either positive or

negative depending on whether the probability λ_m of losing money is smaller or greater than the probability λ_B associated with the alternative form of wealth.

The foregoing analysis is essentially a sketch in that in the solution to the portfolio rule forming the basis for the analysis the terms J_W^m and J_W^B depend on the portfolio rule ξ. The term J_W^m is the first partial derivative of the consumer-investor's indirect utility function with respect to wealth at the point where the risk of losing money has been realized, i.e. where $M = \xi W = 0$. The value of the term thus depends on the proportion ξ. Furthermore, the term J_W^B also depends on portfolio policy for the same reason. Accordingly, this form of solution to the portfolio rule is in fact a non-linear implicit function of the portfolio proportion. By way of an example, it can be noted that, if the consumer-investor's temporary utility function is of logarithmic form, the relevant implicit function is of third order in the cases of the two Poisson processes examined. Thus, in principle, the implicit nature of the solution can have a significant impact on the validity of the interpretations derived from it, one reason being that an explicit solution is generally non-unique and quite complex. However, we do not pay attention here to the problems which may be caused by complexity; rather we assume that the solution is plausible and that the implicit solution illustrates its properties approximately correctly.

2.2.4 A General Model Framework

The two extensions of a modern portfolio model presented above can easily be combined into one model. In such a fairly general model, the total proportion of the demand for money consists of the minimum variance portfolio proportion and four speculative portfolio fractions. Of the latter, the first is associated with the interest rate difference factor, the second with transactions cost differences and the third and fourth with security risks. Using the notation defined above, the portfolio rule of the combined model can be written in the following form:

(25) $\quad \xi = \xi^m + \xi^S + \xi^{\tau}_{\lambda} + \xi^m_{\lambda} + \xi^B_{\lambda}$

In the present analysis, transactions costs are assumed to be riskless. A similar presentation could equally be written for the case in which transactions costs involve (normal) uncertainty.

Finally, we use the general portfolio framework to consider what kind of properties the demand for money has with respect to changes in different exogenous factors. The analysis of the impact of changes in interest rates, adjustment costs and security risks is, in principle, simple, because these appear separately in their own terms in the speculative portfolio. It can easily be shown that in the general portfolio model the elasticities of the portfolio proportion of money with respect to the interest rate difference (elasticity = ε_r), transactions cost difference (ε_a), security risk λ_m (ε_m) and the security risk $\lambda_B(\varepsilon_B)$ of the different forms of wealth are as follows:

(26a) $\quad \varepsilon_r = \dfrac{\xi^S}{\xi} < 0 \qquad\qquad$ if $r_m < r_B$

(26b) $\quad \varepsilon_a = \dfrac{\xi^{\tau}}{\xi} > 0 \qquad\qquad$ if $a_m < a_B$

(26c) $\quad \varepsilon_m = \dfrac{\xi^m_{\lambda}}{\xi} < 0$

(26d) $\quad \varepsilon_B = \dfrac{\xi^B_{\lambda}}{\xi} > 0$

The signs of elasticities have been determined by parameter assumptions corresponding to the conventional view of the properties of different forms of wealth. According to the elasticities, the demand for money diminishes as the (negative) interest rate difference grows and increases as the (negative) transactions cost difference grows. The demand for money also increases if either the security risk inherent in holding money diminishes or the security risk inherent in holding an alternative asset grows. The absolute size of the elasticities depends on the variance-covariance structure of the different factors

and on the consumer-investor's attitudes towards risk and his level of wealth.

The effects of changes in the uncertainty of returns (or possible transactions costs) are much more difficult to determine. As stated above, the increase in uncertainty leads to a fall in the absolute magnitudes of the speculative portfolio proportions. The corresponding impacts on the minimum variance portfolio proportions depend on the sign and size of the correlation coefficient, the sizes of standard deviations and on which factor causes the increase in uncertainty (total variance). In the present context (as is frequently the case when applying portfolio theory), it is sensible to assume that the proportions of the minimum variance portfolio are gross substitutes for each other with respect to uncertainty. In that case, the growth in uncertainty caused by the increase in σ_m diminishes the proportion of money in the minimum variance portfolio, whereas growth resulting from an increase in σ_B increases the proportion of money in it. If the total variance grows, for example, through an increase in σ_B, the proportion of money grows, on the one hand, through the minimum variance portfolio substitution and, on the other hand, through a decline in the negative speculative portfolio proportions related to the interest rate difference and the security risk associated with holding money. Similarly, the proportion of money decreases as a result of a fall in the positive speculative proportions related to transactions cost differences and the security risk of the alternative asset.

In principle, the portfolio-theoretic model framework incorporates many properties similar to those of the extended Baumol-Tobin model. The demand for money decreases as a result of a rise in the interest rate on the alternative to money and an increase in the transactions costs of money. However, in many respects the portfolio model has more general properties than the Baumol-Tobin model. First, it can be noted that in the portfolio framework it is possible to analyse a greater number of factors affecting the choice of the forms of wealth than in Baumol-Tobin model. Secondly, the diversification of the forms of wealth in the portfolio model can also be justified by uncertainty factors and not merely by the general convexity of decision problems. Thirdly, the

dependence of the portfolio and its partial elasticities on different factors can be characterized very easily and in a diversified way in the portfolio model. As stated above, an increase in normal uncertainty diminishes absolutely the size of the speculative portfolio proportions and hence increases the demand for the alternative involving a small amount of risk. A similar effect is caused by an increase in the consumer-investor's risk-aversion coefficient (term $- J_{WW} W/J_W$), which indicates that the economic agent has become more cautious. In addition to these features, it can be concluded from the expressions for partial elasticities that all changes in exogenous factors resulting in an increase in the total proportion of the respective form of wealth reduce partial elasticities. Thus, for example, the interest rate elasticity of the demand for money falls, if the difference between the transactions costs of money and the alternative means of payment grows. Similarly, changes reducing the proportion of the form of wealth being examined result in an increase in partial elasticities. Hence, the transactions cost elasticity of the demand for money grows, if the difference in interest rates between various forms of wealth increases.

If we adhere to the assumptions determining the signs of the speculative portfolios, the dependence of the partial elasticities of the demand for money on the parameters and the signs of these relations can be expressed as follows:

$$\varepsilon_r = \varepsilon_r [\, r_B - r_m, \quad a_B - a_m, \quad \lambda_m, \quad \lambda_B \,]$$
$$ - \qquad\quad - \qquad\quad + \qquad -$$

$$\varepsilon_a = \varepsilon_a [\, r_B - r_m, \quad a_B - a_m, \quad \lambda_m, \quad \lambda_B \,]$$
$$ + \qquad\quad + \qquad\quad + \qquad -$$

$$\varepsilon_m = \varepsilon_m [\, r_B - r_m, \quad a_B - a_m, \quad \lambda_m, \quad \lambda_B \,]$$
$$ + \qquad\quad - \qquad\quad - \qquad +$$

$$\varepsilon_B = \varepsilon_B [\, r_B - r_m, \quad a_B - a_m, \quad \lambda_m, \quad \lambda_B \,]$$
$$ + \qquad\quad - \qquad\quad + \qquad +$$

The relationships between elasticities and parameters allow a fairly
wide range of interpretations of the demand for money. According to the
relationships, developments in financial markets and payment techniques
change the properties of the demand for money through several channels.
For example, a widening in the interest rate differential between
alternative forms of holding wealth (a factor reducing the profitability
of holding money) diminishes the interest rate sensitivity of the demand
for money, whereas it increases its sensitivity to changes in other
factors. By contrast, a widening in the transactions cost differential
(a factor increasing the profitability of holding money) increases the
sensitivity of the demand for money to changes in the transactions
cost differential, while it reduces its sensitivity to changes in
other factors.

2.3   The Impact of Qualitative Factors on the Demand for Means
      of Payment

According to the analysis above, in the Baumol - Tobin and portfolio
models the demand for means of payment is determined merely on the
basis of factors directly affecting costs and alternative returns.
Clearly, however, the demand for means of payment can also be affected
by factors the return and cost effects of which are either difficult
or impossible to quantify in money terms. For example, the effecting
of a payment in an anonymous way may be a circumstance which is highly
appreciated by many economic agents. It is frequently claimed that the
importance attached to the presentation of anonymity explains a
significant part of the large per capita quantities of currency in
circulation in different countries.

In principle, it is possible to quantify the value or utility inherent
in the anonymity of payment in some way in both the Baumol - Tobin and
general portfolio models. To demonstrate this, let us assume that
perfect anonymity can be attained when payment is effected in money.
By contrast, means of payment which are alternatives to money involve
payment techniques in which the payer and the payee are identified and
registered automatically. It is further assumed that some payers effect

payments - for example, those related to tax evasion or criminal activities - the detection of which leads to penalty costs. The size of penalty costs at the aggregate level depends on how large a proportion of transactions are subject to sanction and on how many such transactions are observed.

The extended version of the Baumol - Tobin model can be simply re-interpreted under conditions based on the above assumptions. Let λ be defined as the combined probability that a transaction effected with a means of payment which is an alternative to money is subject to the sanction that it has been observed and that γ_L is a penalty cost. It is also asummed that the payment in money is effected with perfect anonymity, i.e. the probability that transaction subject to sanction which is effected in money will be detected is always zero. If, for the sake of simplicity, it is further assumed that, under such conditions, payment by a means of payment which is an alternative to money does not involve any other transactions costs, the extended Baumol - Tobin model as presented in chapter 2.1 corresponds exactly to the situation being examined.

In the case of the general portfolio model, the effects of anonymity can be quantified in the same way. Security risks are interpreted as the penalty risks attached to the effecting of transactions subject to sanction. It is assumed that $\lambda_m = 0$ and that the magnitude of the penalty always equals the item of wealth subject to sanction. Thus, the general portfolio model describes the consumer-investor's behaviour in a situation in which detection of a transaction subject to sanction as illustrated above leads to a penalty.

An alternative way of taking into account factors which are difficult to measure and evaluate is to treat them directly as utility through the preferences of a representative economic agent.[6] Although this

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[6]Cf. Feenstra (1986), who demonstrates the linkages between demand for money functions when they are derived, on the one hand, by incorporating money directly in the utility function of the economic agent and, on the other hand, by modelling liquidity cost functions for the entire portfolio.

method does not eliminate the problem of measuring values, it transforms the measurement basis from monetary units into utility indicators. The latter is more general than measurement in terms of money in the sense that although it ranks different alternatives, it does not measure quantitative differences between alternatives. In order to demonstrate this approach, a simple model based purely on the transactions demand for money is developed in the following which takes into account differences in the anonymity of payment related to the alternative means of payment and their effects on the wealth of a representative economic agent. The model is based on the characteristics idea developed by Lancaster (1971), according to which consumers do not demand commodities as such but rather the services rendered by them.

We examine a static situation in which the representative consumer gains utility from consumption and disutility from paying for consumption in that the transaction is registered in the payment system. This disadvantage can be called the publicity disutility and denoted by symbol A. The representative consumer's preferences in consumption (C) and the publicity disutility are assumed to be as follows

(27) $U(C,A) = \log C - \beta \log A$

The consumer may pay for consumption either with money or by a giro transfer. The payment of one payment unit in money gives rise to costs of c_m units while payment by giro transfer gives rise to costs of c_B units ($c_m > c_B$). If the income level is defined as I, the price of consumption as p and the payment proportion of money as ξ, the consumer's budget constraint is of the form

$$[c_m\xi + c_B(1 - \xi)]pC \leqslant I$$

In addition, it is assumed that payment with money and by giro transfers gives rise to different kinds of publicity disutility. For the sake of simplicity, it is assumed, in particular, that payment with money causes disutility of h_m units and payment by giro transfers disutility of h_B units ($h_B > h_m$). Hence, "the production technology of the publicity disutility" is as follows

$$A = h_m\xi + h_B(1 - \xi)$$

The representative consumer's utility maximization problem can now be formulated in the following way

(28) $\max\{\log C - \beta\log[h_m\xi + h_B(1 - \xi)] - \lambda[c_m\xi + c_B(1 - \xi)]pC - I)\}$

   $\{\xi,C\}$

The first order conditions of the problem specify the following solution as the optimal payment proportion of money

(29) $\xi = \dfrac{\beta c_B}{(1 + \beta)(c_m - c_B)} + \dfrac{h_B}{(1 + \beta)(h_m - h_B)}$

The solution indicates that, on the basis of the above parameter assumptions, the first term on the right hand side is positive whereas the second term is negative. Since short positions are not allowed at the aggregate level, the magnitudes of parameters must meet the following conditions:

   $0 < \xi < 1 \Rightarrow$

   $- \dfrac{h_B}{h_m - h_B} < \dfrac{\beta c_B}{(c_m - c_B)} < - \dfrac{h_B}{h_m - h_B} + 1 + \beta$

As regards the optimal payment proportion of money, it can be stated that it depends negatively on the cost of paying with money c_m and positively on the cost of giro transfers c_B. Furthermore, the proportion of money depends negatively on the coefficient of disutility of paying with money h_m and positively on the coefficient of disutility of giro transfers h_B. Finally, the utility function parameter related to the publicity disutility β has a positive effect on the payment proportion of money. An obvious explanation therefore is that an increase in β increases the weight of the publicity disutility in the consumer's objectives and hence favours the use of a payment method involving less disutility.

The properties of the simple qualitative model are quite plausible, so that the analytical framework should be feasible as such and merit further development. In principle, it is possible, for example, to include the qualitative analysis as part of the general dynamic portfolio model, in which case qualitative properties would obviously produce more speculative partial portfolios in the optimal portfolio policy.

2.4 Conclusion

In the foregoing sections of the demand for money and other means of payment has been viewed from a fairly large number of perspectives. We started by examining the quantity theory of the demand for money, according to which exchange in the economy takes place either solely or at least to a substantial extent using money as the medium of exchange. According to the quantity theory, the demand for money arises primarily as a result of transactions needs. On the other hand, the demand for money is also affected by the level of interest rates, because the economic agent foregoes interest on alternative forms of wealth by holding money balances for his transactions needs.

It was noted that the problem with the quantity theory is that the theory places very strong emphasis on money as the only medium of exchange. In practice, however, there are a number of various forms of wealth which can either be used almost equally well as money as means of payment or can be converted into money at very low costs. Moreover, the nominal returns on close substitutes for money are generally higher than the nominal return on money balances (zero).

It was not possible in this context to solve the problems related to the quantity theory. Rather, their characteristics and potential solutions were analyzed in previous sections by means of partial models. In summarizing the partial analysis, it can be stated that there is every reason to regard the demand for money and means of payment as a result of a fairly general choice decision between different forms of wealth. Accordingly, a general model describing the

behaviour of the demand for money should be primarily based on the portfolio-theoretic framework. However, the general model should not, like the traditional portfolio model, be confined merely to an analysis of the effects of the return/risk properties of different forms of wealth. On this basis, it seems clear that a fairly general demand model for money and means of payment in general, mainly based on the portfolio model, can be specified by the implicit demand function for the following arbitrary means of payment (M_i):

$$(30) \quad M_i = M_i[r_i, \; r, \; a_i, \; a, \; \lambda_i, \; \lambda, \; A_i, \; A, \; \pi, \; W, \; S^2, \; R_a]$$

According to equation (30), the demand for money depends on the rates of return on all included assets (r_i, r), on the transactions costs (a_i, a), loss probabilities (λ_i, λ) and qualitative characteristics of all the assets (A_i, A), on the inflation rate (π) and wealth (scale variable, W), on the risks associated with the portfolio (S^2) and on the risk attitudes of the representative economic agent (R_a). Although equation (30) is obtained here by combining different partial models, it might be possible to genuinely derive it from the basics. However, equation (30) would not serve very well as a starting point for empirical analysis in the sense that it is not possible to set strong a priori restrictions on the parameter estimates based on it. It is known from demand theory that even the signs of comparative statics are hard to pin down in such an elaborate model as (30) and would require very strong assumptions on the signs and magnitudes of different substitution and income effects. Therefore, although one can argue on fairly reasonable grounds in favour of certain comparative statics properties in (30), equation (30) should be regarded more as an extensive list of factors determining the demand for money than as a basis for hypothesis testing.

3   The Demand for Means of Payment in Finland

The demand for cash and other means of payment was outlined above as
part of the choice between different forms of wealth. The demand for a
means of payment was considered to depend on both its own properties
and those of other means of payment and forms of wealth. Besides cash,
it is possible to use cheques, debit and credit cards and bank and
postal giro transfers as payment instruments in Finland. Notes and
coin are, however, the dominant means of payment used in transactions
by the public in Finland. The demand for cash has grown steadily in
absolute terms, though the ratio of currency in circulation to
national income has fallen in recent decades. At present, the ratio of
currency in circulation to GDP is 2.5 per cent, which is probably one
of the lowest figures in the world. The relative fall in the use of
currency reflects the prevalence of alternative means of payment and
the more efficient use of currency in Finland.

Reliable time series on the use of money and the demand for different
types of money have been compiled in Finland for several decades, and
there have been many studies on the demand for money at the aggregate
level (see the survey by Söderlund (1988)). Nevertheless, the use of
alternative means of payment has not been monitored systematically at
the national level. For example, the compilation of data on the use of
various debit, charge and credit cards has only been started in recent
years (see the Finnish Bankers' Association (1985) and (1986)). On the
whole, the monitoring of the use of cards has been defective. For
instance, there is no reliable information available on how many card
transactions have been carried out in retail trade in recent years.
Although some data exist on past card payments in the case of certain
individual companies (e.g. oil companies), the data are sparse and do
not suffice for generalizations covering the total economy. This
implies that the empirical examination of the demand for money does
not allow the examination of the effects of other means of payment in
a theoretically optimal way.

This section examines the use of means of payment replacing cash and
the demand for cash in Finland.

3.1 The Use of Means of Payment Other than Cash

In 1985, there were over 3 million plastic cards of various kinds in
use in Finland. In the 1980s, the number of plastic cards has been
increasing substantially. For example, in 1985 alone, the number of
cards increased by 600 000 from the previous year (see Table 1).

TABLE 1.   NUMBER OF PLASTIC CARDS IN FINLAND IN 1984 AND 1985[1]
           (thousands)

Type of card	1984	1985	% change 1984/1985
Bank and multipurpose cards	698	882	+ 26
Cash cards	287	447	+ 56
OK cards	86	99	+ 15
VISA cards[2]	117	165	+ 41
Eurocheque cards	11	10	− 9
Other cards (finance, commercial, oil and other international companies, travel and car hire agencies)	1218	1440	+ 18
Total number of cards	2417	3043	+ 26

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[1] Finnish Bankers' Association (1986).
[2] Without cash facility.

It can be see from Table 1 that the number of cash and VISA cards grew
substantially in 1984 - 1985 reflecting the changes that occurred in
the financial markets in the 1980s. Sharpened competition and pressures
to rationalize financial operations have contributed the increased use
of new means of payment and banking automation. Another important
factor contributing to the growth in the number of plastic cards in
Finland has been the improved opportunities to use them (i.e. their
higher liquidity). For example, the ratio of the number of OK and VISA
cards to outlets accepting cards as means of payment has been stable
for the whole of the 1980s; in 1980-1985 the number of outlets per
card varied around 0.05. This suggests that the public has responded
to the increased liquidity of cards by acquiring more of them as
additional means of payment. The intensity of card use seems to have
increased along with the growth of the number of outlets accepting
cards. For example, in 1980 an average cardholder used his/her OK or
VISA card about 26 times whereas in 1985 the frequency was already 31.

Recent developments in the use of plastic cards in Finland have mainly had an impact on payment instruments that can be regarded as close substitutes for cards. The demand for means of payment depends on their ability to correspond to the needs of their users in different payment situations and it is natural that new means of payment first replace those payment instruments that are similar to them. This can be seen from Table 2, which shows the use of payment instruments other than cash in Finland in 1984 and 1985.

TABLE 2.   THE USE OF PAYMENT INSTRUMENTS OTHER THAN CASH IN
           FINLAND, VOLUME OF TRANSACTIONS (MILLIONS) IN 1984-1985[1]

	1984	1985	% change 1984/1985
Giro transactions			
Bank giro	223	239	+ 7
Postal giro	133	136	+ 2
Reference bank giro	51	55	+ 8
Total	407	430	+ 6
Other transactions			
Cheques	72	64	− 11
Bank cards	11	23	+ 109
Total	83	87	+ 5

[1] Finnish Bankers' Association (1985) and (1986).

According to Table 2, bank card payments mainly displaced payments by cheque in 1985. In 1985, the number of cheque transactions fell by 8 million (11 %) from the previous year. The number of transactions in which either a bank card or a cheque was used as a means of payment grew at the same rate as other non-cash payments. This suggests that the bank card has until now been the closest substitute for cheques. On the other hand, the growth in the use of plastic cards has resulted in a marked fall in the number of instalment payments. Statistics on the substitution of plastic card payments for other payments are not, however, sufficient to allow statistical analysis on this matter.

On the whole, the present evidence on new payment instruments seems to
suggest that plastic cards will mainly displace cheques and instalment
payments in the near future.[7] This is to be expected because it is
precisely these payment instruments that have proved to be the most
costly either for banks (cheques) or for users (instalment payments).
Clearly a stage will be reached when cheques and instalment payments
will have been displaced by plastic cards to such an extent that this
process will no longer lead to any significant increase in the number
of plastic cards. The question then arises as to whether or not
plastic card payments will then start to displace cash in large
quantities. The answer will depend on the experiences obtained with
the use of cards and on their advantages in comparison to cash. It
will also partly depend on the coverage of the EFT POS system in
Finland at that time.

3.2 The Demand for Cash in Finland

During the last 20 years the demand for currency in Finland has been
increasing in absolute terms even though the ratio of currency in
circulation to GDP has decreased by over 2 percentage points during
this time. In Chart 1 the relative shares of currency in circulation
and currency held by the public (currency in circulation - currency
held in banks) in GDP are shown for the period 1963 - 1987.

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[7]An instalment payment can be regarded as a means of payment which is
a combination of those payment instruments that are typically used for
making instalment payments. Thus, it is this combination which has
been displaced by plastic cards.

CHART 1. RATIOS OF THE SHARES OF CURRENCY IN CIRCULATION AND
CURRENCY HELD BY THE PUBLIC TO GDP

1 Currency in circulation
2 Currency held by the public
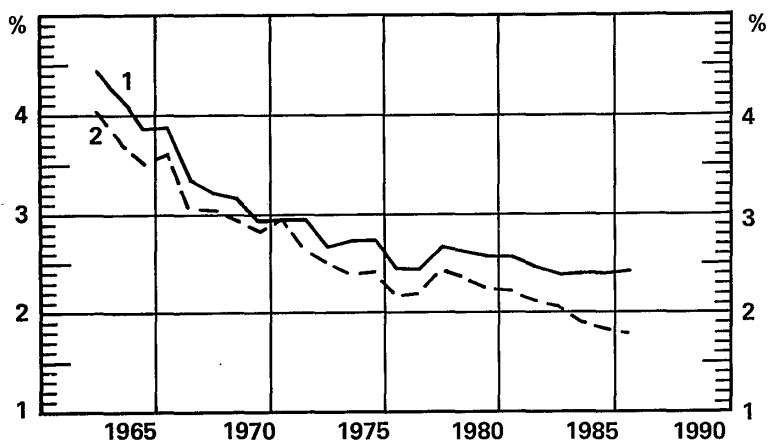
It can be seen from Chart 1 that both the relative shares of currency
in circulation and currency held by the public in GDP have been falling
quite steadily throughout the period. In the 1980s some kind of wedge
appears to have emerged between the two indicators. This is due to the
till-money credit arrangement whereby the central bank lends to the
banks at a zero rate of interest the currency held in the vaults of the
banks. This arrangement was introduced to rationalize the transportation,
storage and distribution of notes and coin in the economy. Compared
internationally the amount of currency in circulation in Finland is
one of the lowest in relative terms. This is partly due to Finland's
highly developed bank and postal giro system, which both companies and
individuals have used for making payments since the 1950s. Chart 1
suggests that the increasing number of plastic card transactions in
the 1980s has not had a major impact on the use of currency in the
economy, and this is a trend which seems likely to continue.

When it comes to analyzing empirically the demand for different denominations in Finland, there are at least two fundamental questions that have to be answered. The first is whether or not the currency in circulation is a homogeneous aggregate of different denominations. If denominations can be regarded as homogeneous, it is possible to estimate an aggregate demand function for money and obtain the demand for different denominations from their internal distribution within the currency in circulation. On the other hand, if different denominations cannot be regarded as homogeneous, it is necessary to analyze their demand separately from each other. In the theoretical analysis it was shown that elasticities with respect to the same exogenous variables for means of payment that are not homogeneous normally differ from one another.

It is quite clear in practice that, for example, the smallest and largest denominations, are not homogeneous means of payment for economic agents. A transaction of 1 000 markkas is almost certainly never effected with 20 000 five-penni coins. For many other denominations it is easy to point out non-homogeneities in payment situations. The use of different vending machines is one factor that creates heterogeneity. Though the differences between denominations are not always so obvious (for example, in the case of 50 markka and 100 markka notes), it seems to be a natural point of departure in empirical analyses to assume that different denominations are individual means of payment. It is then possible to test whether the denominations respond in a homogeneous fashion to changes in important exogeneous variables affecting the demand for money in general.

Another important question relates to the effects of the inflation rate and the real rate of growth on the demand for various denominations in the market. When the price level in the economy rises, it gradually leads to a situation where the value of the smallest denomination is very small. Ultimately, the smallest denomination may lose its purchasing power to such an extent that it is used only as an accounting unit and is removed from the circulation - typically because the number of such coins demanded grows too large relative to the economic significance of the denomination. In a similar fashion, with the growth of the economy

and the rise in the price level there will be an increasing number of transactions the value of which exceeds the largest denomination. In the course of time this leads to a situation where the largest denomination is regarded as too small and a new, bigger denomination is issued.

In principle, the way in which the mix of denominations changes is an endogenous process, in which the behaviour of the authorities determining the mix could be explained by, for example, the real rate of growth and inflation. Thus, these factors would affect the demand for individual denominations in such a way that small denominations removed from circulation would have to be replaced by some other denominations in transactions and large denominations put into circulation would displace those already in the market.[8]

The supply side effects described above on the quantity of denominations in the market are, in principle, considerable. As regards the empirical analysis of the demand for different denominations however, this process is quite slow under conditions of low inflation. Thus, its effects appear rarely and more or less as discrete shifts in the demand for denominations. Because such incidences are normally quite infrequent, only very long time series would contain enough observations on the way in which the process affects estimation. Because of the short period to be used in subsequent estimations, the supply-side effects on the demand for different denominations will be evaluated by the use of appropriate dummy variables.

Ruling out a fully explicit treatment of the pure supply side effects, some other potential effects of inflation and real growth on money demand need to be discussed. This can be conveniently done in the context of the simple portfolio framework extended to include transaction costs, studied in Section 2.2.2.

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[8] Inflation and the real rate of growth of the economy could have fully analogous, albeit minor, effects on the quantities of denominations, as a result of the fact that companies operating cash dispensers 'inflate' the denominations of coins and notes used in dispensers along with the nominal growth of the economy.

First, it is a general result that if the demand for money is determined according to the extended portfolio model of Section 2.2.2, then the rate-of-return elasticities of the demands for different denominations are generally not the same. If the real rates of return are the relevant opportunity cost measures in the model - i.e. if the investor values real rather than nominal wealth in his portfolio decisions - then the inflation elasticities of the demands for different denominations also differ. Therefore, the demands for each coin and note appear to be heterogeneous with respect to inflation.

Similarly, if the demand for money is governed by the above-mentioned model, then all the demand functions appear at first sight to have the same scale variable (wealth, income, consumption) elasticity - equal to one in the most standard case. This prediction may be seriously misleading, however. Technical progress in transactions technology is likely to reduce the transactions costs of each portfolio item. This implies gradually declining demands for all denominations under standard demand-theoretic assumptions. If the scale variable is a good proxy for technical progress, then the estimated income elasticities of all demand functions would be substantially lower, perhaps even negative for some denominations. What is important, moreover, is that the income elasticities adjusted for technical progress are again generally denomination-specific.

3.3 Demand for Different Denominations: Empirical Models

Compared to the volume of empirical research on the aggregate demand for money, there are relatively few empirical studies on the demand for individual denominations. The studies on denominations have been more or less exploratory and the models used in estimations have not been derived from the demand behaviour of economic agents. Two different approaches have been applied in empirical work:

1)   The aggregate demand for money is first modelled and the share of each denomination is then determined separately from the aggregate model, see Lempinen (1980) for an example of this kind of an application.

2)   Each denomination is modelled as an individual means of
       payment, allowing for the fact that elasticities of demand
       with respect to income, interest rates and inflation may differ
       from one model to another; see Fase and van Nieuwkerk (1977)
       for an example.

The first approach is based on the assumption that different
denominations are perfect substitutes for each other as means of
payment. The second approach stems from a portfolio-theoretic model
which allows for potential differences in the substitutability
properties of various denominations. In fact, the first approach
differs from the second in that it sets a priori restrictions on the
income and rate-of-return elasticities in the demand equations.
Starting from less restrictive assumptions, the second approach makes
it possible to test which of the above approaches is supported by the
data. Estimating separate equations as a simultaneous equations system
takes into account the fact that the demand for different
denominations can be interrelated.

Similar problems attach to the empirical modelling of the demand for
denominations as regards choosing the model specification and appropriate
explanatory variables as in the case of modelling the aggregate demand
for money, see e.g. Goldfeld (1973) and (1976), Artis and Lewis (1974)
or Judd and Scadding (1982). In addition, if notes and coins are
regarded as separate means of payment, portfolio-theoretic considerations
become important. Earlier in this paper the demand for money was
regarded as part of the general demand for means of payment and it was
argued to depend, among other things, on the rates of return on all
assets included, on transactions costs, on the inflation rate and
wealth, on the rates associated with the portfolio and risk attitudes
of the representative agents. In actual empirical work the data
usually limits the way in which the theoretical considerations can be
taken into account. In this paper the demand for different
denominations is assumed to be determined in the long-run by a scale
variable, represented by private consumption in real terms, and two
opportunity cost measures, the 3-month rate of interest and the rate
of inflation. Owing to the lack of appropriate data, our empirical

models include only part of the relevant explanatory factors of a
portfolio-theoretic model. If the actual underlying model explaining
demand behaviour is essentially portfolio-theoretic, the simple model
specifications used in the estimation may turn out to be inadequate.
In particular, if any of the explanatory factors are correlated with
the omitted variables in the portfolio model difficulties may emerge.
Therefore, the model used in this paper should be regarded as a first
attempt towards a more complete model based on a portfolio framework.

A potential problem in subsequent estimations stems from the
interrelationship between the chosen scale variable (private
consumption in real terms) and technical progress. Improvements in
transactions technology reduce transactions costs of different means
of payment and gradually lead to declining demands for all denominations.
Therefore, if the scale variable and technical progress are positively
correlated, it is possible to obtain rather low, or even negative,
income elasticities from estimations if technical progress is omitted
from the models to be estimated. To study the importance of this
effect models with and without a proxy for technical progress will be
estimated in subsequent empirical analyses.

Another important question is related to the opportunity cost measure.
Do the data support either the nominal or the real rate of return as a
relevant opportunity cost of holding money? In other words, does the
rate of inflation have an independent effect on the demand for
denominations in addition to that of the nominal interest rate?

Finally, we discuss a question related to choosing the unrestricted
portfolio model as the appropriate starting point. Namely, is there any
evidence in favour of the hypothesis that different denominations are
homogeneous in the sense that the long-run income and rates-of-return
elasticities are the same for each denomination? A model in which the
long-run income and rates-of-return elasticities are restricted to be
equal for each denomination is evaluated against an unrestricted model
in order to see which of the model specifications is supported by the
data.

A dynamic model specification for each denomination is chosen to allow for possible adjustment processes in empirical estimations. For more general specifications, see Hendry and Mizon (1978) or Pagan (1987) for further discussion. The basic model for any denomination j ($j=1,\ldots,m$) can be written as follows:[9]

$$(31) \quad \log d_{jt} = \alpha_{0j} + \alpha_{1j} \log d_{jt-1} + \beta_{0j} \log pc_t + \beta_{1j} \log pc_{t-1}$$

$$+ \gamma_{0j} \log sr_t - \gamma_{1j} \log sr_{t-1} + \delta_{0j} \log inf_t - \delta_{1j} \log inf_{t-1}$$

$$+ \theta_{1j} inds2_t + \theta_{2j} inds3_t + \theta_{3j} inds4_t + u_{jt}$$

where d_{jt} is the demand for denomination j in real terms. pc_t represents the scale variable measured by private consumption in real terms. In the estimations the scale variable was also approximated by GDP but the results did not differ from those in which private consumption was used. sr_t and inf_t represent opportunity costs of holding the denomination j; sr_t is the 3-month rate of interest and inf_t is the rate of inflation. The variables $indsk_t$ ($k=2,3,4$) are seasonal indicators and are determined as follows:

$$(32) \quad indsk_t = \begin{cases} 1, & \text{if the period } t \text{ refers to the kth quarter} \\ 0, & \text{otherwise} \end{cases}$$

u_{jt} represents the error term in the model. It is easy to see that the dynamic model (31) includes a static model as a special case when the coefficients for lagged variables are all zero. The long-run income and interest rate effects can be written as

$$(32) \quad \frac{\beta_j}{\alpha_j} = \frac{\beta_{0j} + \beta_{1j}}{1 - \alpha_{1j}}$$

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[9]A more detailed discussion on estimating dynamic models of the form (31) is provided by Wickens and Breusch (1988).

$$(33) \quad \frac{\gamma_j}{\alpha_j} = \frac{\gamma_{0j} + \gamma_{1j}}{1 - \alpha_{1j}}$$

$$(34) \quad \frac{\delta_j}{\alpha_j} = \frac{\delta_{0j} + \delta_{1j}}{1 - \alpha_{1j}}$$

By rewriting equation (31) it is possible to estimate the long-run parameters α_j, β_j, γ_j and δ_j directly. For estimation convenience it is useful to write equation (31) as follows:

$$(35) \quad \Delta logd_{jt} = \alpha_{0j} - \alpha_j logd_{jt-1} + \beta_j logpc_t - \beta_{1j} \Delta logpc_t$$

$$+ \gamma_j logsr_t - \gamma_{1j} \Delta logsr_t + \delta_j loginf_t - \delta_{1j} \Delta loginf_t$$

$$+ \theta_{1j} inds2_t + \theta_{2j} inds3_t + \theta_{3j} inds4_t + u_{jt}$$

where Δ represents the first difference operator. Note that (35) is merely a linear transformation of (31), having the same constant and error term in both cases. Estimating the demand for denominations using the model specification (35) has many advantages. First, because the model explains changes in the denomination in circulation, the coefficient of determination measures the explanatory power of the model in a more meaningful manner than it would if a level form equation were used. Secondly, the difference transformation substantially reduces the multicollinearity problem connected with lagged regressors in dynamic model specifications. Finally, the long-run coefficients can be directly estimated from the model specification. To calculate standard deviations for the long-run elasticities and other transformed variables, a theorem in Rao (1971, p. 387), which relates the variance-covariance matrix of parameters of interest to the variance-covariance matrix of estimated parameters, is used.

A possible problem arising in estimating equation (35) separately for different denominations arises from the fact that the demand for a specific denomination may be partially influenced by the demand for

other denominations. In addition, there may be common factors affecting the demand for all denominations that have been omitted from the model (35). These factors may then appear in the error term u_{jt} and errors in different equations (j=1,...,m) may be correlated with each other. These problems require special measures in estimation. The method of estimating seemingly unrelated regressions (SURE) developed by Zellner (1962) has been used in this paper. The simultaneous equations systems for notes and coins have been estimated separately. Quarterly data from the fourth quarter of 1975 to the second quarter of 1987 are used in estimations.

Estimation results are reported in the following order. First, the results for the demand equations in which the separate impact of technical progress on demand has not been taken into account in any particular manner are shown for coins (Table 3) and notes (Table 4). Second, the results for models that include a proxy for technical progress are reported (Table 5 for coins and Table 6 for notes). The long-run income and rates-of-return elasticities implied by the technical-progress-augmented model specification are reported in Table 7. Finally, the test results for the hypothesis of the equality of long-run income and rates of return elasticities of different denominations are discussed.

Thus, Table 3 reports the SURE-estimation results for the demand equations for coins. The variable $ind5_t$ affecting the demand for 5 markka coins only takes into account the discrete shift in the supply of 5 markka coins in 1984. It obtains the value of one after the first quarter of 1984 and the value of zero in other periods. DW refers to the Durbin-Watson test statistic for AR(1) residuals and Q(M) refers to the Ljung-Box Q-statistic for the general autocorrelation of residuals (M is the number of autocorrelations). Q is treated as a chi-square with M degrees of freedom. The covariance-variance matrix of residuals is reported in Appendix 1.

TABLE 3. ESTIMATION RESULTS FOR THE DEMAND FOR COINS.
ESTIMATION PERIOD 1975:4 - 1987:2, N = 47

Dependent variable $\Delta_1 \log d_t$

Independent
variables

	5 pennis	10 pennis	20 pennis	50 pennis	1 markka	5 markkas
Intercept	2.2786	0.5949	-.6737	.4877	.4246	.4824
	(7.37)	(3.10)	(-3.48)	(1.49)	(1.56)	(.51)
$\log d_{t-1}$	-.3406	-.1612	-.3665	-.1831	-.1489	-.5542
	(-7.49)	(-3.53)	(-5.83)	(-3.32)	(-2.31)	(-25.83)
$\log pc_t$	-.1672	-.0255	.1770	.0040	.0263	.1098
	(-6.73)	(-1.48)	(5.20)	(.13)	(.75)	(1.12)
$\Delta_1 \log pc_t$	.1459	.1569	.0029	.0940	.2687	-.0093
	(1.71)	(1.87)	(.04)	(.63)	(2.02)	(-.02)
$\log sr_t$	-.0313	-.0143	-.0181	-.0199	-.0337	-.1047
	(-3.94)	(-2.03)	(-2.82)	(-1.58)	(-3.03)	(-2.80)
$\Delta_1 \log sr_t$	0.0129	.0047	.0021	.0040	.0184	.0474
	(1.71)	(.67)	(.33)	(.33)	(1.67)	(1.40)
$\log inf_t$	-0.0158	-.0113	.0005	-.0023	.0009	.0084
	(-3.48)	(-2.52)	(.12)	(-.29)	(.12)	(.34)
$\Delta_1 \log inf_t$	-0.0180	-.0085	-0.0247	-.0044	-.0315	.0681
	(-1.48)	(-.69)	(-2.32)	(-.21)	(-1.69)	(1.23)
$inds2_t$	.0068	.0131	.0106	.0421	.0359	.0174
	(1.12)	(2.18)	(1.93)	(3.97)	(3.69)	(.61)
$inds3_t$	.0136	.0256	.0239	.0309	.0315	.0036
	(3.80)	(7.31)	(6.74)	(5.17)	(5.41)	(.24)
$inds4_t$	.0214	.0294	.0383	.0577	.0740	.0163
	(3.21)	(4.46)	(6.40)	(4.96)	(6.96)	(.52)
$ind5_t$						.9260
						(25.93)
$\bar{R}^2$	.75	.81	.88	.78	.90	.94
DW	2.03	2.19	2.33	2.51	2.38	2.01
Q(18)	12.05	10.15	24.31	14.90	17.81	7.66

It can be seen from Table 3 that the simple model specifications explain the variation in the demand for coins relatively well. The coefficient of determination ($\bar{R}^2$) adjusted for degrees of freedom varies between 0.75 and 0.94 among different specifications. According to the DW and Q test-statistics autocorrelation of residuals does not create problems in any of the model specifications. The adjustment patterns and responses to changes in income, nominal interest rate and inflation vary across equations. This is one indication of the differences coins possess as means of payment.

The long-run coefficient for the income effect, measured by the coefficient of $logpc_t$, is negative for the two smallest denominations. One possible explanation for this result arises from the fact that the scale variable (measuring the income effect in our model) may reflect differences in transactions costs between different means of payments and that holding the two smallest denominations has simply become more expensive relative to other means of payment. This interpretation is to a certain extent supported by the estimation results for the technical-progress-augmented model specifications to be discussed later on in this section.

The long-run nominal interest rate effect (measured by the coefficient of $logsr_t$) is negative and significantly different from zero in most cases. The corresponding effect of inflation (measured by the coefficient of $loginf_t$) is negative and significantly different from zero for the two smallest denominations. According to this result it seems that holding 5 and 10 penni coins involves opportunity costs in real rather than nominal terms.

Table 4 reports SURE-estimation results for the corresponding demand equations for notes.

TABLE 4. ESTIMATION RESULTS FOR THE DEMAND FOR NOTES.
ESTIMATION PERIOD 1975:4 - 1987:2, N = 47

Dependent variable $\Delta_1 \log d_t$

Independent
variables

	10 markkas	50 markkas	100 markkas	500 markkas
Intercept	1.1763	.5170	2.4350	-.2006
	(1.50)	(.66)	(2.69)	(-.12)
$\log d_{t-1}$	-.1075	-.0741	-.2645	-.0862
	(-2.37)	(-2.11)	(-4.00)	(-2.42)
$\log pc_t$	-.0743	-.0158	-.0608	.0619
	(-1.13)	(-.23)	(-.80)	(.31)
$\Delta_1 \log pc_t$	.4844	-.1849	-.1874	2.6023
	(2.02)	(-.66)	(-.51)	(3.46)
$\log sr_t$	-.0104	-.0111	-.0653	.0382
	(-.52)	(-.47)	(-2.08)	(.57)
$\Delta_1 \log sr_t$	-.0005	-.0038	.0302	-.0330
	(-.02)	(-.16)	(.98)	(-.53)
$\log inf_t$	-.0064	-.0127	.0082	.0460
	(-.50)	(-.83)	(.40)	(1.16)
$\Delta_1 \log inf_t$	-.0464	-.0520	-.0445	-.2206
	(-1.37)	(-1.32)	(-.86)	(-2.10)
$inds2_t$	.0712	.1361	.1352	-.0727
	(4.18)	(6.83)	(5.11)	(-1.36)
$inds3_t$	.0397	.0120	.0039	.0095
	(4.15)	(1.11)	(.27)	(.33)
$inds4_t$	.0901	.0834	.1201	-.0821
	(4.80)	(3.80)	(4.15)	(-1.40)
$\bar{R}^2$	.84	.79	.77	.55
DW	2.80	2.78	2.87	1.85
Q(18)	24.60	25.29	35.11	18.57

It appears from Table 4 that the demand equations for notes also perform relatively well as far as the explanatory power of the models is concerned. The coefficient of determination varies between 0.55 and 0.84. The 500 markka note obtained the smallest $\bar{R}^2$ reflecting the fact that this particular note was only introduced in the market in 1975 and was therefore new to the public for some time during the estimation period. There do not seem to be any serious problems with autocorrelation of residuals according to the DW and Q statistics. The covariance-variance matrix of residuals is reported in Appendix 1.

The long-run nominal interest rate effect is negative and significantly different from zero for the 100 markka note whereas the corresponding inflation rate effect is not significantly different from zero in any of the model specifications. This result supports the hypothesis that the nominal rather than the real rate of return is the relevant opportunity cost of holding notes in the long run.

In Table 5 the estimation results for the technical-progressaugmented demand equations for coins are reported. It is assumed that technical progress follows an exponential growth path represented by a trend in our logarithmic model specifications. This is the standard way of approximating autonomous technical progress in estimating production functions.

TABLE 5. ESTIMATION RESULTS FOR THE DEMAND FOR COINS.
ESTIMATION PERIOD 1975:4 - 1987:2, N = 47

Dependent variable $\Delta_1 \log d_t$

Independent variables	5 pennis	10 pennis	20 pennis	50 pennis	1 markka	5 markkas
Intercept	2.0978 (3.72)	-.4169 (-.59)	-.7369 (-1.30)	-1.6638 (-1.66)	-.0325 (-.04)	-2.4283 (-.89)
$\log d_{t-1}$	-.3512 (-5.75)	-.2719 (-3.27)	-.3876 (-5.59)	-.3804 (-4.95)	-.1938 (-2.94)	-.5587 (-26.21)
$\log pc_t$	-.1447 (-2.24)	.1108 (1.21)	.1897 (2.58)	.2999 (2.47)	.0972 (.92)	.4324 (1.44)
$\Delta_1 \log pc_t$	.1363 (1.53)	.0905 (1.00)	-.0069 (-.08)	-.0655 (-.44)	.2315 (1.67)	-.1629 (-.39)
$\log sr_t$	-.0323 (-3.70)	-.0156 (-2.32)	-.0181 (-2.83)	-.0152 (-1.30)	-.0349 (-3.16)	-.1044 (-2.83)
$\Delta_1 \log sr_t$	.0132 (1.71)	.0059 (.87)	.0024 (.37)	.0038 (.34)	.0191 (1.75)	.0414 (1.22)
$\log inf_t$	-.0160 (-3.49)	-.0129 (-2.95)	.0004 (.11)	-.0044 (-.61)	.0017 (.24)	.0031 (.13)
$\Delta_1 \log inf_t$	-.0184 (-1.50)	-.0050 (-.42)	-.0247 (-2.28)	-.0052 (-.27)	-.0316 (-1.70)	.0583 (1.05)
$inds2_t$	.0064 (1.03)	.0102 (1.70)	.0103 (1.84)	.0352 (3.53)	.0336 (3.46)	.0161 (.57)
$inds3_t$	.0135 (3.68)	.0235 (6.50)	.0232 (6.43)	.0272 (4.84)	.0300 (5.22)	.0064 (.41)
$inds4_t$	.0212 (3.17)	.0277 (4.37)	.0380 (6.35)	.0535 (4.97)	.0721 (6.84)	.0170 (.55)
$ind5_t$						.9262 (26.33)
trend	-.0002 (-.36)	-.0010 (-1.52)	-.0000 (-.05)	-0.0022 (-2.48)	-.0004 (-.59)	-.0023 (-1.11)
$\bar{R}^2$	.74	.82	.88	.81	.90	.94
DW	2.01	2.09	2.29	2.34	2.33	2.02
Q(18)	11.29	9.01	23.85	15.80	18.14	9.07

It appears from Table 5 that the general properties of the model are similar to those in Table 3. As regards the trend variable itself in Table 5, it is significantly different from zero for the 50 penni coin only. However, the trend has a negative effect on the demand for all denominations and the inclusion of the trend has changed the long-run income effects in the expected direction. The negative long-run income effect for the 5 penni coin has become smaller in significance as well as in absolute value and the negative income effect for the 10 penni coin has become positive. The positive income effects have become stronger for all the other denominations. These results strongly suggest using the transactions-costs-augmented portfolio model in empirical analyses. It seems that, since the mid 1970s, the transactions costs of other means of payment have been diminishing relative to those of coins. This has decreased the relative demand for coins during this period. Including the trend does not result in any change in the conclusions about the nominal interest rate and inflation rate effects in the long run from those made from Table 3.

Table 6 reports the estimation results for the technical-progressaugmented demand equations for notes.

It appears from the table that, also in the case of notes, the trend variable has a negative effect on the demand for all denominations. What is significant about the inclusion of the trend variable is the fact that now all the long-run income effects have become positive. Thus, it seems that the changes in the relative transactions costs of different means of payment have been affecting the demand for notes (as well as that for coins) since the mid-1970s. In particular, our results suggest that holding currency has become more expensive relative to other payment instruments, thus decreasing the relative demand for currency in recent years. Including the trend has not changed the long-run nominal interest rate and inflation rate effects from those in Table 4.

TABLE 6.   ESTIMATION RESULTS FOR THE DEMAND FOR NOTES.
            ESTIMATION PERIOD 1975:4 - 1987:2, N = 47

Dependent variable $\Delta_1 \log d_t$

Independent
variables

	10 markkas	50 markkas	100 markkas	500 markkas
Intercept	-1.5902 (-.95)	-1.8897 (-.96)	-1.9080 (-.82)	-6.0393 (-.82)
$\log d_{t-1}$	-.2523 (-3.08)	-.1642 (-2.60)	-.4867 (-5.23)	-.0462 (-.71)
$\log pc_t$	.3114 (1.49)	.3037 (1.29)	.5865 (2.02)	.6759 (.87)
$\Delta_1 \log pc_t$	.2207 (.85)	-.3703 (-1.26)	-.5280 (-1.50)	2.3654 (2.94)
$\log sr_t$	-.0101 (-.53)	-.0081 (-.35)	-.0854 (-3.01)	.0570 (.80)
$\Delta_1 \log sr_t$	-.0027 (-.14)	-.0079 (-.35)	.0381 (1.39)	-.0479 (-.74)
$\log inf_t$	-.0173 (-1.31)	-.0235 (-1.47)	.0223 (1.21)	.0441 (1.11)
$\Delta_1 \log inf_t$	-.0519 (-1.63)	-.0585 (-1.53)	-.0654 (-1.41)	-.2457 (-2.25)
$inds2_t$	.0652 (4.03)	.1328 (6.90)	.1185 (4.95)	-.0746 (-1.40)
$inds3_t$	.0364 (4.00)	.0154 (1.45)	.0065 (.52)	.0136 (.46)
$inds4_t$	.0878 (5.00)	.0845 (4.01)	.1123 (4.40)	-.0827 (-1.41)
trend	-.0040 (-2.00)	-.0032 (-1.52)	-.0051 (-2.33)	-.0057 (-.81)
$\bar{R}^2$	.85	.80	.81	.54
DW	2.70	2.69	2.74	1.94
Q(18)	23.10	23.28	31.42	21.48

In Table 7 the estimated long-run income, nominal interest rate and inflation rate elasticities are reported for the technical-progress-augmented demand functions for notes and coins.

TABLE 7.   LONG-RUN INCOME, INTEREST RATE AND INFLATION RATE
           ELASTICITIES FOR COINS AND NOTES

Denomination	Income elasticity	Interest rate elasticity	Inflation rate elasticity
5 pennis	0.0	-0.09	-0.05
10 pennis	0.0	-0.06	-0.05
20 pennis	0.49	-0.05	0.0
50 pennis	0.79	0.0	0.0
1 markka	0.0	-0.18	0.0
5 markkas	0.0	-0.19	0.0
10 markkas	0.0	0.0	0.0
50 markkas	0.0	0.0	0.0
100 markkas	1.21	-0.18	0.0
500 markkas	0.0	0.0	0.0

0.0 = coefficient not significantly different from zero at
       5 per cent level of significance

Table 7 shows that for most denominations the long-run real income elasticities failed to be significantly different from zero at the 5 per cent significance level. Only for 20 penni and 50 penni coins and 100 markka notes were statistically significant real income effects detected: all these income effects were positive, varying between 0.49 for the smallest and 1.21 for the highest denomination. Once better measures for differences in transactions costs between means of payment than the trend can be included in the model specifications, one can expect stronger income effects to emerge among those denominations that failed to show income effects in these estimations. The significant long-run income effects are in accordance with earlier empirical studies on aggregate demand for money in Finland; see

Söderlund (1988). The long-run nominal interest rate elasticity is significant in 6 cases, varying between -0.05 and -0.19 for different denominations. Previous empirical work on aggregate money suggests interest rate elasticities around these magnitudes. What is different in these estimations is the fact that interest rate elasticities are allowed to vary between denominations. The long-run inflation rate elasticity is not significantly different from zero in most cases. Only for the two smallest denominations is a small, negative effect of the magnitude of -0.05 found. This result suggests that it is the nominal rather than the real rate of return that determines the opportunity cost of holding currency.

Finally, to test for the homogeneity of different denominations, a simultaneous equations system in which the long-run income, interest rate and inflation rate elasticities have been forced to be equal in each equation has been estimated for both coins and notes. In other words, trend-augmented model specifications in Tables 5 and 6 have been estimated by restricting the coefficients for the following groups of variables in each equation to be the same: $logd_{t-1}$, $logpc_t$, $logsr_t$, and $loginf_t$. Thus, the coefficients for the lagged $logd_t$ in each equation have been restricted to be the same, the coefficients for income variables $logpc_t$ have been restricted to be the same and so forth. This procedure means that the long-run coefficients for these variables become the same in each equation.

The likelihood ratio test was performed to see whether or not the data supports the imposed restrictions. The chi-square test statistic for coins with 20 degrees of freedom obtained the value of 189.9, clearly rejecting the null hypothesis of homogeneity. The corresponding test statistic of the value of 31.2 with 12 degrees of freedom for notes is not equally powerful as that for coins. This partly reflects the fact that the long-run effects for notes failed in most cases to be significantly different from zero. In the restricted estimation the long-run income effect for coins was 0.41, the nominal interest rate effect -0.05 and the inflation rate effect -0.01. The long-run coefficients for notes failed to be significantly different from zero. These estimation results are available from the authors on request.

This essay has examined the demand for notes and coins. It has been argued that the demand for various denominations may respond differently to changes in real income, interest rates or the inflation rate and that improvements in transactions technology (affecting relative transactions costs) may have a significant impact on the demand for different means of payment. In fact, our empirical results tentatively suggest that technical progress has reduced the transactions costs of other payment instruments relative to currency in Finland since the mid-1970s leading to a negative impact on the relative demand for denominations during this period. It also seems that the data reject the hypothesis that the denominations are homogeneous in their long-run responses to income and rates-of-return measures. Furthermore, the fact that our simple model specifications fitted better for coins than for notes suggests that the demand for notes has been more strongly affected by the use of other means of payment than the demand for coins. To be able to study these effects more directly than has been done in this essay, a more complete portfolio-theoretic model than ours should be estimated. No doubt, when data on other payment instruments becomes readily available, further research will be able to shed light on some of the questions that have been raised here.

APPENDIX 1.   COVARIANCE-VARIANCE MATRIX OF RESIDUALS

Results from Table 3:

	5 p	10 p	20 p	50 p	1 m	5 m
5 p	.52E-04					
10 p	.39E-04	.51E-04				
20 p	.21E-04	.24E-04	.42E-04			
50 p	.53E-04	.61E-04	.65E-04	.16E-03		
1 m	.48E-04	.44E-04	.55E-04	.12E-03	.13E-03	
5 m	.35E-04	.21E-05	.97E-05	.24E-04	.11E-04	.11E-02

Results from Table 4:

	10 m	50 m	100 m	500 m
10 m	.42E-03			
50 m	.30E-03	.57E-03		
100 m	.46E-03	.69E-03	.11E-02	
500 m	.51E-03	.40E-03	.42E-03	.41E-02

Results from Table 5:

	5 p	10 p	20 p	50 p	1 m	5 m
5 p	.52E-04					
10 p	.37E-04	.47E-04				
20 p	.21E-04	.23E-04	.42E-04			
50 p	.48E-04	.53E-04	.59E-04	.14E-03		
1 m	.48E-04	.42E-04	.53E-04	.11E-03	.13E-03	
5 m	.31E-04	-.43E-05	.73E-05	.52E-06	.30E-05	.11E-02

Results from Table 6:

	10 m	50 m	100 m	500 m
10 m	.37E-03			
50 m	.28E-03	.53E-03		
100 m	.36E-03	.55E-03	.84E-03	
500 m	.43E-03	.35E-03	.29E-03	.40E-02

p = pennis
m = markkas

III THE ROLE OF THE CENTRAL BANK IN THE PAYMENT SYSTEM

1 Introduction

Nowadays, in all countries the functioning of the payment system is
regulated and controlled by the central bank (or generally speaking
the state) under the prevailing institutional circumstances. In
addition, the monetary system is the main channel through which the
central bank influences macroeconomic developments. Despite the fact
that the authorities in different countries have adopted a basically
similar view about the central bank's role in the monetary economy,
the question of the necessity of intervention by the central bank
continues to be a key issue in discussion and disputes in economics.

Broadly speaking, the issue of the necessity of central bank
intervention and the form it takes can be examined from two angles.
From the point of view of microeconomic theory, the payment system is
one production or service sector in a market economy. Hence, the
question of the necessity of government intervention in the functioning
of the payment system reverts to the question as to whether or not there
are market imperfections in the market for payment services. If the
market for the services provided by the payment system meets the basic
assumptions which are required in a Walrasian model of a competitive
economy, intervention by the central bank is unnecessary. The payment
system functions in a Pareto-optimal fashion without external control
and its efficiency cannot be enhanced through regulation by the
central bank. If, in an imaginary situation like this, control by the
central bank is not fully successful, the level of welfare in the
economy is lower than that attainable without intervention.

From the point of view of macroeconomics, the payment system is largely
of indirect importance. Questions relating to the efficiency of the
system itself are regarded as of secondary importance, even to the
extent that it is the convention in macroeconomics to assume that the
costs of the monetary system are zero. The indirect importance of the
payment system arises from the fact that the state of the payment system
determines the nature of the demand for money function prevailing in

the economy. As, in principle, the central bank can regulate either
the supply of money or interest rates, the demand for money function
partially determines the central bank's opportunities to influence
macroeconomic phenomena. The impact of changes in the supply of money
or interest rates on real aggregates in the economy depends largely on
such factors as how elastic relative prices are and how homogeneous is
the information which economic agents have at their disposal. Generally
speaking, it can be said that if relative prices are not fully elastic
or if there are information differences between economic agents, the
central bank is able to even out real variations in economic conditions
by means of a suitable intervention policy. It is worth noting here
that price rigidities and information differences are just two market
imperfections in microeconomic theory. Hence, the macroeconomic
perspective is essentially a small part of the microeconomic efficiency
view. However, these points of view have traditionally been separated
in economic research into two almost completely separate problem areas.

In this essay, the problem of the necessity of control and regulation
by the central bank's is dealt with primarily from the micro-theoretic
point of view. The basic question is then whether or not the central
bank can enhance the economic efficiency of the payment system either
by controlling or regulating the functioning of the system or by
producing payment services itself. The problem is analysed from two
angles. First Section 2 considers mainly the problem of the basic
stability of the monetary economy associated with the system of fiat
money. The problem arises from the fact that the market value of money
generally exceeds its commodity value many times over.[1] Section 3 deals
with a number of standard market imperfections and their effects on the
need for intervention. Finally, it is noted that in certain instances
the social preferences represented by the central bank may require a
system differing from the payment system arising through the market.

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[1]The instability problem is dealt with in connection with
micro-theoretic issues, because the instability problem is basically a
micro one.

2 Payment Systems and the Stability of the Monetary Economy

It is a widely accepted view among economists that of the three basic
types of payment systems (fiat money, commodity money and the
accounting system of exchange), the fiat money system involves a
fundamental instability problem due to the nature of money. The basic
property of fiat money is that its market price exceeds its production
costs many times over. This has been justified on the grounds that
such an arrangement has made it possible to reduce the total costs of
the payment system. Thus the issue of fiat money gives rise to profits
- seigniorage. Exceptionally large profits on a continuing basis are
possible only if the issue of money is in the hands of a perfect state
monopoly or a very strong, protected private monopoly. As a rule,
central banks are solely responsible for the supply of base money, so
that seigniorage is part of governments' budget financing.

A general principle applying to all economic activity is that
operations generating high profit margins tend to expand. Seigniorage
also creates incentives for the expansion of the money supply
irrespective of whether the supply of money is the central bank's
monopoly or not. In fact, central banks have frequently been
criticized by monetarists on the grounds that, on average, the supply
of money has grown too rapidly, so that rates of inflation have been
unnecessarily high. However, a factor constraining central banks and
governments in general in expanding the supply of money is the concern
that a very rapid inflation could undermine citizens' faith in the
institution of fiat money. In an extreme case, inflation could lead to
hyperinflation, the collapse of the fiat money payment system and the
loss of the rationalization gains yielded by it.

If the supply of fiat money were privatized so that it became the
responsibility of the banking sector operating under totally
unregulated competitive conditions, the constraint on money expansion
by government described above would probably cease to be effective.
Each individual bank would perceive that it could increase its balance
sheet profitably without liquidity risks. In so doing, they would not
take into account the fact that their competitors behave in precisely

the same way. As a result, the total supply of money would grow to
such an extent that the entire fiat money system could be jeopardized
by a rapidly accelerating inflation.

The idea that seigniorage makes the fiat money system potentially
unstable if the supply of money is in the hands of a competitive
banking sector is probably the strongest single argument requiring the
intervention of the central bank or the government in the monetary
system. It is an idea that has been accepted, by Friedman (1959) and
Patinkin (1965), among others.

As regards the empirical significance of the instability risk, it can
be stated that actual periods of hyperinflation during the current
century have been associated with general crisis situations.
Hyperinflation emerged, for example, in the closing stages or immediate
aftermath of the World Wars in certain countries (see Cagan (1956) and
Sargent (1982)). They usually have their origins in the need of states
to finance large budget deficits by issuing notes. Very high rates of
inflation, which cannot be regarded as true hyperinflations, have also
appeared under more normal conditions. In the 1980s, high rates of
inflation have been recorded in, for example, Israel and certain Latin
American countries (see, e.g. Dornbusch - Simonsen (1987)).

Several other arguments supporting the view that the central bank is
able to improve the functioning of the monetary economy by controlling
the supply of money and regulating the activities of banks and other
financial institutions have been put forward in economics. According
to Friedman (1959) and Friedman and Schwartz (1986), there are three
other good reasons apart from the fundamental reason why the central
bank should keep the monopoly of issuing money in its own hands. First,
even if a private monetary system were based on commodity money, the
real costs of a commodity money system are so high that the issuers of
currency would gradually run down their commodity stocks functioning
as a back-up for the system and hence shift towards a fiat money
system. This would mean an increase in the risk of instability in the
economy. Secondly, it has proved difficult to create an agreement
system under which payment obligations would serve efficiently as

means of payment without involving major fraud and default problems. Particularly in transactions between individuals, the use of money issued by the central bank is a much less risky payment method than an obligation signed by one party to surrender some real wealth against the commodity received from the other party. Thirdly, money seems to be a natural monopoly commodity in terms of production, which in some sense requires that an upper limit be set on the quantity of money in circulation (because of the risk of inflation). Vaubel (1984) states that, through its impact on the price level, an increase in the quantity of money alters the decision-making situation of all economic agents.

Vaubel (1984) also notes that a case can be made out for a monopoly because of the significant seigniorage which money generates for the state. He further claims that the supply of money should be under the central bank's control, because a private banking system could be fundamentally unstable. In addition, regulating the supply of money makes it possible to even out the effects of the private sector's potentially unstable behaviour on the economy.[2]

Important counterarguments against the claim of the inherent instability of a private fiat money system have been put forward by B. Klein (1974) and L. White (1984), among others. According to Klein, each individual competing bank would also be so concerned about the quality of its money that it would produce no more than the amount required for optimal quality. White has presented historical evidence showing that a fiat money system organized by the private banking sector has functioned faultlessly (in Scotland at the turn of the 18th and 19th centuries). An extreme liberalization view is represented by

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[2]Of the extensive research on this subject in recent years, mention can be made of the studies by Saving (1976), Yeager (1983), Fama (1983), White (1983), King (1983), Fischer (1986a) and Goodhart (1987), which deal with the question of money as a private or public institution, the studies by Claassen (1985) and Selgin - White (1987), which examine the development of monetary institutions through the market, the studies by Dwyer - Saving (1986), Fischer (1982) and Bordo (1986b), which consider state revenue from the monopoly of currency supply, and the studies by Buiter (1986), Giovannini (1986) and McKibbin - Sachs (1986), which analyze the efficiency and conditions for efficiency of different monetary systems.

the so-called Austrian school (see, e.g., Hayek (1976) and Fischer (1986a)), according to which efficient institutions also arise through the mechanism of perfect competition. According to this view, the monopoly of the central bank in the supply of money is suboptimal from the point of view of society's welfare and probably leads to greater cyclical fluctuations in the economy than if the supply of money were implemented through the mechanism of a competitive economy.

We examine the problem of the instability of the monetary economy possibly arising from seigniorage in terms of a simple model framework. The model is a simplified version of the basic model developed by B. Klein (1974) but is dynamic and incorporates uncertainty. It is assumed that a representative consumer consumes over two periods (consumptions C_1 and C_2) and utilizes liquidity services derived from the holding of money (liquidity services N_1 and N_2). The consumer has certain incomes y_1 and y_2 at his disposal during the two periods. Monies (M_{11}, M_{12}, M_{21}, M_{22}) produced by two competing firms in the two periods yields liquidity services as follows:

$$N_1 = \beta_1 M_{11} + \beta_2 M_{21}$$

$$N_2 = \beta_1 M_{12} + \beta_2 M_{22}$$

β_1, $\beta_2 > 0$ are the liquidity service coefficients of money.

Let the utility function of the representative consumer be of Cobb-Douglas form:

(1) $\quad U(C_1, C_2, N_1, N_2) = \alpha \log(C_1^\gamma C_2^{1-\gamma}) + (1-\alpha)\log(N_1^\delta N_2^{1-\delta})$

Utility maximization under such conditions implies, among other things, that on the demand side, the marginal utilities of the monies produced by different manufacturers must cost the consumer an equal amount. Hence, the price ratio between the monies produced by different companies in each period must be

$$\frac{P_{11}}{P_{21}} = \frac{P_{12}}{P_{22}} = \frac{\beta_1}{\beta_2}$$

If the price ratio differs from the ratio between the marginal utilities, the consumer, owing to the constant marginal utility of money, uses only the cheaper money.

With respect to the supply side, it is assumed, for the sake of simplicity, that the supply of consumer goods is an exogenous constant C during the two periods. Let the cost functions of the firms producing money be as follows

(2a) $K_1 = K_1(M_{11}, M_{12})$

(2b) $K_2 = K_2(M_{21}, M_{22})$

According to this assumption, money is a conventional good, the production of which involves costs. If the firms producing money seek to maximize their profits, the price ratios between the monies produced by each firm are as follows

$$\frac{P_{11}}{P_{21}} = \frac{K_{11}}{K_{21}}$$

$$\frac{P_{12}}{P_{22}} = \frac{K_{12}}{K_{22}}$$

K_{ij} = the marginal cost of the production of money j by firm
i = 1,2; j = 1,2.

When the market is in equilibrium the price ratios of the supply and demand sides must be equal.

In the basic situation described above, the monies produced by different firms are ordinary commodities, and the supply of money by the firms operating under perfect competition does not cause any special problems

for the economy. The production of money costs the economy exactly as much as the consumer is willing to pay for it on the basis of the marginal utility accruing to him from the use of money.

In the following, we change the assumptions concerning the basic situation so as to allow for the possibility of fundamental instability arising through competitive supply. Thus we assume that there is uncertainty concerning the value of money during the second period. This is due to the fact that firms are assumed to be able to produce money at standard costs of production with probabilities λ_1 and λ_2 in the second period and without any costs with probabilities $1-\lambda_1$ and $1-\lambda_2$. The latter corresponds to a situation in which the production of fiat money is normally assumed to take place. In order to construct as simplified a situation as possible, it is assumed that the firms' cost functions are of the following form:

$$(3a) \quad K_1 = \begin{cases} b_1[M_{11} + (1-r)M_{12}] & \text{with probability } \lambda_1 \\ \\ b_1 M_{11} & \text{with probability } 1-\lambda_1 \end{cases}$$

$$(3b) \quad K_2 = \begin{cases} b_2[M_{21} + (1-r)M_{22}] & \text{with probability } \lambda_2 \\ \\ b_2 M_{21} & \text{with probability } 1-\lambda_2 \end{cases}$$

An improvement in profitability (a fall in costs) of r per cent occurs in the cost functions in the second period with probabilities λ_1 and λ_2 and an improvement of 100 per cent with probabilities $1-\lambda_1$ and $1-\lambda_2$. The representative consumer has expectations about the probabilities λ_1 and λ_2 and certain information about the parameters. The economy is in ex ante equilibrium before the second period, if $b_2/b_1 = \lambda_1 \beta_2 / \lambda_2 \beta_1$. In an ex ante equilibrium, relative prices in the current and the coming period are determined in terms of the numeraire commodity.

It is assumed that during the second period a state is obtained in which $\lambda_2 = 0$, i.e. the production costs of one of the firms producing

money fall to zero. If the public still maintains its ex ante
expectations about probability λ_2, the relative prices in accordance
with ex ante equilibrium are maintained in the market. The firm
producing money at zero costs is then in a position to gain infinite
profits by issuing more money as long as the ex ante price convention
remains in the market. However, as a result of the huge flow of new
money into the market, the money produced by the zero-cost firm becomes
a free good in the economy in the second period. If the representative
consumer knew beforehand that production costs were going to fall, he
would already reduce his demand for the money produced by the other
firm in the first period and would not be prepared to pay anything for
it in the second period. Hence, the emergence of seigniorage depends
crucially on the price ratios of the commodities remaining unchanged
in the market as a result of consumers' imperfect information, even
though relative production costs undergo sharp changes.

The transformation of the money produced by the other firm into a free
good in the second period means that the prices of other commodities
are inifinite ex post, if this money is used as the unit of account in
the economy. The price system would then lose its significance
entirely. The occurrence of such a situation is generally regarded as
highly undesirable, although in our simple model framework it would
not cause any direct harm to the economy.

In the example examined, the stability of the monetary economy clearly
depends on how the production of money is organized. Under highly
simplified assumptions, if the supply of money is in the hands of
competing private firms, this could lead to a very unstable price
system because profit maximization would force firms to expand their
supply of money immediately when it was marginally profitable. From
the point of view of the government, seigniorage is essentially an
alternative way of taxation. Thus its maximization is not meaningful
as a separate objective. Rather the government may consider that its
policy of money supply should take sufficient account of the role of
money as a measure of values.

It is important to realize that the instability problem only concerns
the fiat money system. It has been shown in a number of different

contexts that both a fully covered commodity money system (in which money is backed 100 per cent) and a partly covered one (in which money is backed less than 100 per cent) guarantee the maintenance of the price of money at a finite level, thus precluding the emergence of hyperinflation and the collapse of the monetary economy in all circumstances. Since, in theory, real security can be provided just as well by the central government as by the private sector (for example, by maintaining a sufficient stock of raw materials or goods), intervention by the government is not necessarily needed for assuring the stability of a backed monetary system. Similar views have been put forward at various times and in various contexts by Friedman (1951), Johnson (1968), Hall (1982), White (1983) and Obstfeld and Rogoff (1983), among others.

We now briefly examine the stability problem of the monetary economy in the light of the analysis by Obstfeld and Rogoff. In their model, the representative consumer maximizes the present value of his welfare. The consumer's planning horizon extends to infinity and the value of his welfare index is determined on the basis of consumption c_t in each period and the liquidity services yielded by real balances $m_t = M_t/P_t$. The consumer receives income from holding real capital (income = rK_{t-1}) and in the form of transfers from the government (h_t).

The consumer can hold his wealth in the form of either real capital or money. The total amount of real capital is given (= k), because consumer goods cannot be exchanged for real capital. The objective function of the representative consumer is of the following form:

$$(4) \quad W = \sum_{t=0}^{\infty} \beta^t [u(c_t) + v(m_t)]$$

$\beta < 1$ is the discount factor.

In the objective function, consumption and liquidity services appear separately for the sake of simplicity, and it is assumed to be well-behaved. The consumer maximizes the target (the discounted present value of utility) under the wealth constraints. The flow and stock constraints are as follows:

(5a) $A_t - A_{t-1} = P_t rk + (Q_t - Q_{t-1})k + P_t h_t - P_t c_t$

(5b) $A_t = M_t + Q_t k$

A_t = nominal wealth
P_t = price of consumer goods
Q_t = price of capital

The first-order conditions related to the consumer's problem are

(6a) $\dfrac{u'(c_t)}{P_t} = \dfrac{v'(m_t)}{P_t} + \dfrac{\beta u'(c_{t+1})}{P_{t+1}}$

(6b) $u'(c_t)q_t = \beta u'(c_{t+1})(q_{t+1} + r)$

$q_t \equiv \dfrac{Q_t}{P_t}$ = the real price of capital

According to condition (6a), the marginal utility of money in consumption must be the same in the current period and the following period, if the marginal transfer of wealth required by the comparison is made by investing in money. Condition (6b) requires the equality of marginal utilities also in the case where the transfer of wealth is carried out by investing in real capital.

An essential part of the analysis of the stability of the model's equilibrium paths is the interpretation of the price q_t of real capital and the time paths of real balances m_t. It is assumed that the supply of money remains at a constant level M_1, in which case monetary policy does not contribute to the potential instability of paths.

It can be shown that the only solution path of the price q_t of real capital which is consistent with equilibrium in all markets is the steady-state solution $q_t \equiv \bar{\bar{q}} = \beta r/1-\beta$ in all periods. Other paths of the price of real capital, which all lead either to infinity or zero, can be excluded by means of various transversality arguments.

By contrast, it is difficult on theoretical grounds to restrict the
multiplicity of interpretations related to the time path of real
balances. Although real assets have a finite steady-state solution
(which is implicitly determined by the condition
$m[u'(y) - v'(m)] = \beta u'(y)m$; y is the output of the economy), there
also exist other solutions of m compatible with general equilibrium.
Some of these solutions result in non-positive real balances (and
hence to an infinite price level) in finite time. It can be shown that
these solution paths implying hyperinflation can be excluded only if
the following condition holds:

(7) $\lim_{m \to 0} m\, v'(m) > 0$ <=> $\lim_{m \to 0} v(m) = -\infty$

According to the condition, nominal money must play a very dominant
role in the utility function of the representative consumer. Hence
hyperinflations in the economy can be omitted from the set of possible
equilibrium solutions only in the event that the representative
consumer is unwilling to surrender even worthless money against
infinite commodity compensation. Accordingly, money must be an extreme
necessity for the representative consumer of the economy, so as to
totally rule out the possibility of an unstable monetary economy.

It is difficult to regard as realistic preferences according to which
fiat money is a necessity. It is clear on the basis of the foregoing
that the risk of instability in the monetary economy exists as long as
the money in use is unbacked. The general price level of the economy
can explode as a result of speculative hyperinflation. The problem of
instability cannot arise, however, if the government is able to
guarantee the convertibility of money into real capital at some
relative price. Let as assume that the government, on demand, exchanges
one monetary unit for ϵ units of real capital. As the price of real
capital is in equilibrium at the steady-state level $\bar{q}$, the guaranteed
value of the monetary unit is $\epsilon\bar{q}$ consumption units. It can then be
shown that the price level of the economy can never exceed $\bar{\bar{P}} = 1/\epsilon\bar{q}$.
The stability coefficient ϵ can also be freely chosen, so that
$\bar{\bar{P}} > \bar{P}$ ($\bar{P}$ is the price level corresponding to the steady-state solution

m, when the supply of money is M_1), in which case it can be claimed
that the backed system also functions partially. Furthermore, the
back-up arrangement can be implemented on an uncertain basis. If the
quantity ε is exchanged in each period with an independent probability
π, the price level $\bar{P}$ remains the highest possible price which can
prevail in the economy.

By keeping real reserves as a back-up for money in circulation and
being prepared, whenever necessary, to exchange stored commodities for
money, the government can thus eliminate the possibility of an unstable
price level in the economy. Since in the model examined the nature of
money and the back-up arrangement did not involve any aspect on the
basis of which the control of the monetary system was exclusively in
the hands of the government, the above results also hold true with
respect to a private monetary system in which there is a credible
reserve arrangement.

The results of the analysis by Obstfeld and Rogoff are complemented in
an interesting way by Weil's study (1987). Weil examines the
determination of the price level (the price of money) in an economy of
overlapping generations, in which the demand for money is based on the
fact that money is the only institution in the model by means of which
resources can be transferred over time. Money has no real backing.
Rather, the price of money remains positive (and the general price
level finite) because economic agents believe that money will also
have value in the future. Weil shows that if economic agents expect
money to become worthless during the following period with the
probability 1-q, there exists the highest possible degree of lack of
confidence (subjective probability) 1-Q that the demand for money will
be maintained. The probability 1-Q depends (negatively) on how much
the efficiency of the economy can be enhanced by the intertemporal
transfer of resources allowed by money. Consequently, it can be stated
that although money has direct real backing in the model, the loss of
efficiency resulting from the non-use of money corresponds as a
mechanism to reserves.

Black (1970), Fama (1980), Hall (1982), White (1984) and several other
economicsts have argued that this problem does not arise at all in a

pure accounting system of exchange, because only giro transfers are
used as means of payment and their values and execution costs are
determined in the market. The introduction of giro transfers does not
then involve any extra profits. Rather, transfers are like any
commodities in the economy, whose optimal quantity is determined on
the basis of supply and demand in market equilibrium. This corresponds
to the equilibrium conditions in the commodity money system examined
above.

By contrast, in a mixed system in which both money and other means of
payment are used in addition to giro transfers, the problem of
instability may exist in principle. It is typical of mixed systems
that the measurement of values is based on monetary units. If the money
used in such a system is fiat money, all payments are then effected
indirectly in units of fiat money, Thus conceptually this system is a
system of fiat money, in which case the problem of instability must be
inherent in it to some extent. In a mixed system, the instability
problem may be less severe than in a fiat money system, because,
depending on the collateral practices of banks, giro transfers are
partially or even totally covered. When wealth is transferred from one
account to another, the bank really transfers part of its claims from
one account-holder to another. If these claims have real collateral,
the right to a share of these is also transferred between the parties.
If the bank should, for one reason or another, go into liquidation and
all its debtors are unable to pay off their debts, the bank's depositors
would receive part of the real collateral.

2.1 Summary of the Instability Issue

The system of fiat money seems to involve the fundamental risk that
economic agents will lose their confidence in money. In the extreme
case, this may result in hyperinflation, whereupon the exchange value
of money approaches zero. The basic reason for the instability risk is
the great difference between the market and commodity values (production
costs) of money. It is widely accepted among economist that the
production and control of the quantity of fiat money cannot be assigned

to the private sector because of the potentially high profits arising from the difference between market and commodity values. The monetary economy is on a sounder basis if the central bank carries on these activities as a monopoly.

By contrast, the commodity money system does not involve any risk of instability. Though the difference in values mentioned above also arises in the production of commodity money, it does not give rise to any lack of confidence because money can always be exchanged at a fixed price for the commodities backing them. Nor does any risk of instability emerge in a pure accounting system of exchange since it is essentially a commodity money system. Accordingly, safeguarding the stability of the price system does not require a public monopoly under the commodity money system or the accounting system of exchange.

3   The Microeconomic Efficiency of the Payment System

The payment system seems to be steadily developing towards an accounting system of exchange. This being the case, it is superficially apparent - albeit not fully clear - that the instability risk inherent in the monetary economy is diminishing and that the intervention argument based thereupon is losing its importance. However, their may be several other market imperfections present in the market for payment services which could affect the nature of and need for intervention by the central bank. In the following sections we examine imperfect competition, economies of scale, multiproduct economies, administrative pricing, the formation of chains in payment service markets, the external effect of the stability between the activities of individual banks and the entire banking system and differences in the preferences of society and the market.

3.1 Imperfect Competition in the Market for Payment Services

In the following, we examine the production of payment services under different market conditions.[3] It is assumed initially that the (inverse) demand function for payment services $p = p(M)$ behaves well and that there are two firms producing services in the market, whose cost functions are $C_1 = C_1(M_1)$, $C_2 = C_2(M_2)$. If the number of firms is restricted to two and the two rivals follow the Cournot strategy, the firms' maximization problems determining equilibrium in the market are as follows:

(8a) $\max\limits_{\{M_1\}} p(M_1 + M_2)M_1 - C_1(M_1)$

(8b) $\max\limits_{\{M_2\}} p(M_1 + M_2)M_2 - C_2(M_2)$

The first order conditions determining the firms' optimal supply behaviour are

$$p + p'M_1 - c_1' = 0$$

$$p + p'M_2 - c_2' = 0$$

$$p' = \frac{\partial p}{\partial M_1} = \frac{\partial p}{\partial M_2}$$

$$c_1' = \frac{\partial C_1}{\partial M_1}$$

$$c_2' = \frac{\partial C_2}{\partial M_2}$$

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[3]Simple basic models of imperfect competition are applied in the analysis. See, for example, Varian (1978) and Dixit (1986).

The conditions can be rewritten in the following form

(9a) $(1 + \frac{1}{\varepsilon})p = c_1'$

(9b) $(1 + \frac{1}{\varepsilon})p = c_2'$

$\varepsilon = \frac{dM}{dp} \frac{p}{M}$ = price elasticity of demand

According to the conditions, the market price exceeds the marginal cost by the mark-up coefficient. Irrespective of the properties of the cost functions, the mark-up coefficient can be said to determine the extra price in the production of payment services caused by imperfect competition. At the same time, the higher price means a lower equilibrium volume of services than would be the case under perfect competition.

The inefficiency described above is usually associated with markets operating under conditions of imperfect competition. The degree of inefficiency tends to fall when the number of firms operating in the market increases, but generally disappears only in the case where at least one competitive firm has fully frictionless and costless entry to and exit from the market.[4] In the present context, entry into the market is understood in a broad sense to also include the possibility of utilizing and applying the technology corresponding to that used by firms already operating in the market.

Thus, if there are significant barriers to entry or it involves costs, the public sector is, in principle, able to produce the commodities in question more efficiently than the private sector operating under conditions of imperfect competition. To demonstrate this, we use an example to examine the general duopoly model presented above and the similar market situation which arises when there is one private or public monopoly in the market. The following (linear) forms are assumed for the demand and cost functions

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[4]See Chapter 2 in Baumol-Pantzar-Willig (1982).

$$p = p_0 - \gamma M$$

$$c_1 = \alpha_0 + \alpha_1 M_1$$

$$c_2 = \beta_0 + \beta_1 M_2$$

If both firms apply the Cournot strategy in the market, the following equations are obtained for each firm's output, market supply, and the equilibrium market price

(10a) $\quad M_1 = \dfrac{1}{3\gamma} p_0 - \dfrac{2}{3\gamma} \alpha_1 + \dfrac{1}{3\gamma} \beta_1$

(10b) $\quad M_2 = \dfrac{1}{3\gamma} p_0 - \dfrac{2}{3\gamma} \beta_1 + \dfrac{1}{3\gamma} \alpha_1$

(10c) $\quad M \equiv M_1 + M_2 = \dfrac{2}{3\gamma} p_0 - \dfrac{1}{3\gamma} (\alpha_1 + \beta_1)$

(10d) $\quad p = \dfrac{1}{3} p_0 + \dfrac{1}{3} (\alpha_1 + \beta_1)$

If there is only one firm (firm 1) operating in the market as a private sheltered monopoly, the corresponding equations are

(11a) $\quad M = M_1 = \dfrac{1}{2\gamma} (p_0 - \alpha_1)$

(11b) $\quad p = \dfrac{1}{2} (p_0 - \alpha_1)$

If the equilibrium market states are compared, it can be seen that under monopoly conditions, the price is higher and hence market volume smaller than under duopoly conditions.

If the production of payment services is in the hands of a public monopoly and assuming that it is able to operate at the same costs as a private monopoly, the situation changes significantly. Instead of profit maximization, a public monopoly operates according to the zero profit principle. Hence the production of payment services is determined by the condition

$$\pi = (p_0 - \gamma M)M - \alpha_0 - \alpha_1 M = 0$$

The equilibrium market volume and price are now

(12a) $M = \dfrac{1}{2\gamma} (p_0 - \alpha_1) + \varepsilon$

(12b) $p = \dfrac{1}{2} (p_0 - \alpha_1) - \gamma\varepsilon$

$$\varepsilon = \frac{1}{2\gamma} [(p_0 - \alpha_1)^2 - 4\gamma\alpha_0]^{\frac{1}{2}}$$

It can be shown that the market price is lower and the market volume greater than under a private monopoly or a duopoly.

The advantages of a public monopoly seem indisputable in the case examined. However, it should be remembered that the case of free market entry produces precisely the same market solution as the case of a public monopoly. As regards the market for payment services in Finland, the case of free market entry is probably of very little relevance, because the production of payment services seems to take place under conditions of relatively marked and lasting imperfect competition. This may be partly due to the fact that the pricing of payment services is more or less administratively regulated. Many payment services are even free of charge. In such a case, the overall market situation favours firms (banks) which have already developed other profitable activities; the losses incurred in the production of payment services are covered by profits earned from their other activities. A firm entering the market must be able to develop into the same kind of multiproduct firm if it is to be able to compete effectively with those firms already present in the market. Accordingly, the market regime functions in the same way as a monopoly pursuing a predatory pricing policy.[5] This kind of monopoly creates sufficient excess capacity for itself under conditions of increasing returns to

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[5]See, for example, Saloner (1986).

scale, so that it can credibly signal to prospective rivals the unprofitability of entry into the market. The credibility of this message is based on the fact that the incumbent firm can, whenever necessary, exploit its cost advantages to sell its products at prices at which a new entrant cannot operate profitably.

The presence of imperfect competition in the market is also partly due to the fact that banks play a central role in the market. Banking legislation places heavy demands on firms operating in the market and thus acts as an important barrier to entry.

3.2 Economies of Scale in the Production of Payment Services

The presence of imperfect competition in the market is a sufficient reason for the inefficiency of the market, irrespective of the type of cost function governing the activity in question. However, the type of cost function could be of importance in the sense that it may favour a certain market structure. It is generally acknowledged that increasing returns to scale are a fundamental reason for the existence of monopoly power.

If c = c(M) is the cost function related to the production of payment services, increasing returns to scale are said to prevail in production, if

(13) $\dfrac{c(M)}{Mc'(M)} > 1$[6]

According to the condition, in the case of increasing returns to scale, the average unit costs of production exceed marginal costs. The following chart illustrates this situation

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[6]See Chapter 2 in Baumol-Pantzar-Willig (1982).
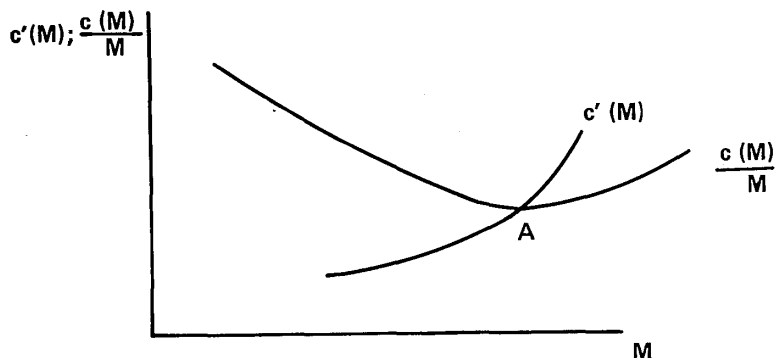
At levels of output lower than the level determined by point A, returns to scale increase, whereas they fall at levels of output higher than A. Increasing returns to scale are typical of industries where the commencement of operations involves high fixed costs and where variable unit costs are low at low levels of output.

The hypothesis is frequently put forward that banking is characterized by economies of scale. This hypothesis has been extensively tested.[7] On the basis of these tests, it is widely believed that economies of scale prevail in small banks but not in large ones. However, these tests have usually concerned only banks' activities related to financial intermediation, and economies of scale in the production of payment services have not been examined at all. Particularly in payment systems based on electronic funds transfer by computers there are fairly strong arguments for the existence of economies of scale in establishments of all sizes. The creation of these systems involves major basic investments, by means of which sufficient capacity is created for handling large volumes of transactions. On the whole, fixed costs are very high in relation to variable costs.

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[7]See, for example, Murray-White (1980) and Mester (1987).

In the market for payment services, a situation of increasing returns
to scale can exist either at the firm level or in the market as a
whole. If it is assumed that all firms operating in the market apply
the same production technology, the lowest average costs are achieved
in the former case at a level of output which is lower than the
equilibrium market demand. Let the volume of output resulting in
minimum costs in this case be M^* and the equilibrium market demand
$\bar{M}$ ($M^* < \bar{M}$). By contrast, in the latter case, the level of output
resulting in minimum costs M^{**} exceeds equilibrium demand $\bar{M}$.

The case of increasing returns to scale at firm level determines the
optimal firm size in the market and provides information on the
structure of the market. If the firms competing in the market apply,
for example, the Cournot strategy, the market price is higher than
minimum unit costs. In equilibrium, all firms produce at a level of
output lower than M^* and it can only be stated that the number of
firms in the markets is $n > \bar{M}/M^*$. As was shown in the general case
above, imperfect competition leads to an inefficient market solution.
If, on the other hand, competitive firms have free entry into the
market, the market price falls to the level of minimum unit costs and
each firm in the market produces within the optimal range. In that
case, the number of companies in the market is $n = \bar{M}/M^*$ or the nearest
whole number above or below this.

If the situation of increasing returns to scale prevails in the market
as a whole, the cost functions of individual firms and that of a
monopoly operating alone in the market are subadditive. Let the cost
function of the representative firm be $c = c(M)$ and the function of
the monopoly $c^m = c^m(M^m)$. If it is assumed, for the sake of simplicity,
that there are n identical companies in oligopolistic conditions and
that $nM = M$, the cost functions of the monopoly and the oligopoly are
related as follows

(14) $c^m(M^m) < nc(M)$

Hence subadditivity of the cost functions of the monopoly and the
oligopoly means that the monopoly is able to produce a given output at

lower unit costs than the oligopoly. Since the monopoly can exploit
economies of scale, market conditions are said to favour the emergence
of a natural monopoly. From the economy's point of view, a natural
monopoly which operates as a private firm is an inefficient organization,
because the price it charges buyers of its services includes a mark-up
on top of the marginal cost of production. In addition, a natural
monopoly is very capable of defending itself against the actions of
rivals. If, for example, a rival firm planned to enter a market
administered by a natural monopoly, it would need to be of very large
size when it launched its operations. In fact, the entrant would only
be able to survive the price war arising in connection with the
struggle for market shares if it's capacity were equal to or larger
than is that of the incumbent monopoly. In that case, there would be
considerable excess capacity in the market as long as the two rival
firms competed against each other. So, as was noted above in the
general case, for efficiency reasons the production of payment services
should be organized as a public activity if favourable conditions
exist in the market for a natural monopoly.

To illustrate the potential macroeconomic importance of economies of
scale, the following example examines the cost savings which might be
achieved for the economy as a whole by introducing a payment system
containing more economies of scale than the present one.

We first examine the payment system as a separate activity in the case
where a (public) monopoly produces payment services at minimum unit
costs. In particular, we consider how differences in funds transfer
technology can affect the emergence of cost differences related to the
payment systems. The approach is based on the finding of cost analyses
of financial services according to which increasing returns to scale
are typical of the production of payment services employing
sophisticated technology whereas constant economies of scale seem to
prevail where manual methods of production are employed (see, for
example, Murray and White (1980)). In other words, production costs
rise relatively less as output increases when an advanced technology
is employed than they do in the case of manual production.

The production of payment and financial services are interconnected in
the sense that these services are frequently provided by the same
economic agents. Hence certain aspects of the production of financial
services may also be relevant for payment services, even if the
production of payment services is examined as a separate activity. As
regards the production of payment services, the above finding suggests
that a sophisticated funds transfer system can be expected to be
associated with greater returns to scale than the less-advanced mixed
system prevailing in many countries.

We consider two payment systems which differ from each other only with
respect to the degree of returns to scale related to their production.
For the sake of simplicity, we make the following assumptions about
the two systems. Different kinds of payment services are combined into
one product called 'payment services' M. It is assumed that two
factors of production x_1 and x_2 are needed for the production of
payment services and that the production technology is of the
Cobb-Douglas form. The purpose of the payment system is to produce the
quantity of payment services M needed in the economy at the lowest
possible cost. This means that, at a certain level of payment services
and with a given technology, the objective is to minimize the costs
incurred to the economy by the payment system. In the case of the
first payment system, this implies searching for a solution to the
following optimization problem:

(15) $\min C_1 = p_1 x_1 + p_2 x_2$ s.t.

(16) $A_1 \, x_1^a \, x_2^b = M,$

where p_1 and p_2 are the prices of factors of production x_1 and
x_2, A_1, a and b are parameters related to the production technology.
The following demand functions for the factors of production are
obtained as a solution to this minimization problem

$$(17a) \quad x_1 = A_1^{-\frac{1}{a+b}} \left[\frac{ap_2}{bp_1} \right]^{\frac{b}{a+b}} M^{\frac{1}{a+b}}$$

$$(17b) \quad x_2 = A_1^{-\frac{1}{a+b}} \left[\frac{ap_2}{bp_1} \right]^{-\frac{a}{a+b}} M^{\frac{1}{a+b}}$$

Thus, the minimum total cost of the payment system is as folows:

$$(18) \quad C_1 = A_1^{-\frac{1}{a+b}} \left[(\frac{a}{b})^{\frac{b}{a+b}} + (\frac{a}{b})^{-\frac{a}{a+b}} \right] p_1^{\frac{a}{a+b}} p_2^{\frac{b}{a+b}} M^{\frac{1}{a+b}}$$

The optimization problem in the second case is very similar to the first one. The same payment services can be produced more efficiently than in the first case because of the greater returns to scale arising in connection with the technology employed. This implies certain assumptions about the size of the parameters a and b. For the sake of simplicity, we assume that the technology parameters of the second payment system are k times the size of the parameters of the first system, i.e. ka and kb, where k is some positive real number. In the second payment system, the minimum total cost of the production of payment services is thus:

$$(19) \quad C_2 = A_1^{-\frac{1}{k(a+b)}} \left[(\frac{a}{b})^{\frac{b}{a+b}} + (\frac{a}{b})^{-\frac{a}{a+b}} \right] p_1^{\frac{a}{a+b}} p_2^{\frac{b}{a+b}} M^{\frac{1}{k(a+b)}}$$

Hence, the difference in costs between the payment systems can be written as follows:

$$(20) \quad C_1 - C_2 = \left[(\frac{a}{b})^{\frac{b}{a+b}} + (\frac{a}{b})^{-\frac{a}{a+b}} \right] p_1^{\frac{a}{a+b}} p_2^{\frac{b}{a+b}} \left[A_1^{-\frac{1}{a+b}} M^{\frac{1}{a+b}} - \right.$$

$$\left. A_1^{-\frac{1}{k(a+b)}} M^{\frac{1}{k(a+b)}} \right]$$

Equation (20) describes the cost difference arising between the two
payment systems in the production of the same payment services, when
the production technology of one system is more efficient than that of
the other. For example, equation (20) could be thought to indicate the
possible cost savings that would arise in the production of the
economy's payment services if the economy introduced a more efficient
funds transfer technology. What kind of cost savings could be achieved
would depend on the volume of payment services produced, the prices of
the factors of production used, the values of the parameters A_1, a and
b and the size of the coefficient k.

So as to obtain an idea of the impact of different factors on the
differences in cost savings between the payment systems described by
equation (20), we analyze the following hypothetical economy. The
value of the output of payment services in the economy is assumed to
amount to FIM 5 billion. The payment system employed in the economy is
characterized by increasing returns to scale (i.e. in equation (20):
a+b > 1). The price ratio between the factors of production is $p_1 = p_2^{-b/a}$
and the value of the production technology parameter A_1 is one. It is
typical of the factors of production x_1 and x_2 that the elasticity of
production with respect to x_2 is greater than the corresponding
with respect to x_1. We compare this payment system with different
values for the parameters a and b to one which is otherwise similar
except that it is more efficient in the sense that the elasticities of
production with respect to the factors of production are k times
greater than the elasticities of the existing system. Table 1 shows
- for different values of the parameters a and b and the coefficient k -
hypothetical calculations of the cost savings which would arise, if
the existing payment system were replaced by one employing a more
efficient production technology.

TABLE 1. AN EXAMPLE OF THE COST SAVINGS ARISING IN THE PAYMENT
          SYSTEM FROM THE APPLICATION OF MORE EFFICIENT PRODUCTION
          TECHNOLOGY WHEN THE VALUE OF THE PRODUCTION OF PAYMENTS
          SERVICES IS FIM 5 BILLION

a	b	a+b	k	Cost saving $C_1 - C_2$	The present value of constant cost savings (t=1,...20) at the discount rate r = 0.07
				FIM billion	FIM billion
0.4	0.7	1.1	1.1	1.1	12.5
0.4	0.7	1.1	1.3	1.3	14.8
0.4	0.7	1.1	1.5	1.3	14.9
0.5	0.8	1.3	1.1	0.05	0.5
0.5	0.8	1.3	1.3	0.06	0.6
0.5	0.8	1.3	1.5	0.06	0.7
0.6	0.9	1.5	1.1	0.00	0.04
0.6	0.9	1.5	1.3	0.01	0.06
0.6	0.9	1.5	1.5	0.01	0.07

Table 1 indicates that the cost savings are greater the smaller are
the returns to scale associated with the prevailing funds transfer
technology. If the technology currently employed is close to the
situation (a + b = 1.1) of constant returns to scale, even a small
increase in efficiency gives rises to major cost savings; e.g. if the
existing payment system is replaced by one in which the values of
parameters a and b are 10 per cent higher (k = 1.1), savings of almost
FIM 1 billion accrue to the economy. If cost savings of this order
could be achieved each year for twenty years, their present value (at
a discount rate of 7 per cent) would amount to FIM 12.5 billion. Thus,
this sum could be invested today in new technology, without giving
rise to any extra costs to the economy.

According to Table 1, the extent of the increase in efficiency, i.e.
whether the coefficient k receives the value 1.1, 1.3 or 1.5, does not
seem to be as of much significance for the total savings achieved as
the level of returns to scale associated with the existing payment
system. If there is a 50 per cent increase in the level of returns to
scale from a + b = 1.1 to (1.5(a+b) = 1.65), the cost savings would
amount to FIM 1.3 billion. This does not differ significantly from

the savings of FIM 1 billion resulting from a 10 per cent rise in the returns to scale. If, on the other hand, the existing system is already operating at a high level of returns to scale, the potential cost savings resulting from the introduction of a more efficient production technology are substantially reduced. For example, if the level of returns to scale is 1.3, a 10 per cent increase means cost savings of FIM 46 million according to Table 1. If this cost saving could be achieved as a steady flow over twenty years, it would be possible to invest FIM 0.5 billion today in more efficient production technology without any additional cost burden. This amount is substantially smaller than the saving, FIM 12.5 billion, achieved at the 1.1 level of returns to scale in the benchmark payment system.

The calculations in Table 1 illustrate a hypothetical economy: simplifying assumptions have been made about the technology employed in the production of payment services and the price ratios between the factors of production. However, the message in Table 1 is very clear: the smaller the returns to scale associated with the existing payment system, the greater are the potential savings for the economy in shifting to a higher level of returns to scale. This suggests that the replacement of manually-based payment services (which to a large extent is what the use of cash is) by a technologically more sophisticated funds transfer system (like an accounting system of exchange) could entail substantial cost savings for the economy. The size of such cost savings depends, inter alia, on the total volume of payment services produced in the economy. In the case of Finland, for example, precise data on the total volume of payment services is not available. This prevents an empirical determination of the values of the technology parameters a and b for the Finnish economy. The difficulties in collecting data are also reflected in international research; it is not easy to find examples of empirical research on the production of payment services, whereas this problem does not arise in the case of research on the production of financial services.

We next examine the effects of returns to scale and changes in them in a situation where the production of payment system services is also reorganized. For the sake of simplicity, we assume that, initially,

payment services are produced by five private banks, which are forced by potential competition to produce services at minimum costs. We further assume that banks are of equal size and apply the same technology, so that the value of each bank's output is FIM 1 billion.

The organization of the payment system is then changed so that, in place of five banks, payment services are now produced by a public monopoly (or a private monopoly operating at minimum costs). In addition, returns to scale increase.

The overall impact of the reorganization and the increase in efficiency on the total costs of producing payment services can also be examined by applying the analytical framework developed above. Using the cost function (18), we directly calculate the costs of production of each individual bank with different parameter values in the case of decentralized production. Because the banks are identical, the total market costs can be derived directly by multiplying the production costs of an individual bank by five. In the case of centralized production and higher returns to scale, the total cost of producing payment services can be calculated directly for different parameter values from the cost function (19). Table 2 shows the cost effects arising in the example as a result of a simultaneous reorganization of the production of payment services and an increase in returns to scale with different parameter values.

TABLE 2. AN EXAMPLE OF THE COST SAVINGS ARISING IN THE PAYMENT
SYSTEM AS A RESULT OF THE CENTRALIZATION OF PRODUCTION
AND THE APPLICATION OF MORE EFFICIENT PRODUCTION
TECHNOLOGY, WHEN THE VALUE OF THE TOTAL OUTPUT OF
PAYMENT SERVICES IS FIM 5 BILLION.

a	b	a+b	k	Cost saving $5C_i - C_m^k$ 1) FIM billion	The present value of steady cost savings (t=1, ..., 20) at the discount rate r = 0.07 FIM billion
0.4	0.7	1.1	1.1	3.0	33.5
0.5	0.8	1.3	1.3	1.7	19.0
0.6	0.9	1.5	1.5	0.9	10.1

1) $5C_i$ = total costs of a decentralized system

C_m^k = total costs of a centralized system (including increase in returns to scale)

The salient point in Table 2 is that the cost savings brought about by
the centralization of the system are very great at all levels of
returns to scale. For all parameter values used in the example, the
savings are in all cases greater than the corresponding savings
reported in Table 1 arising from an increase in efficiency alone.
Savings arising from an increase in efficiency grow very rapidly as
the basic level of efficiency approaches the case of constant returns
to scale (a+b = 1). Close to this point, they are thus greater than
the benefits gained from the centralization of production. By
contrast, the benefits resulting from centralization are still great
in a situation where the level of returns to scale is initially high
(a+b = 1.5) and it is substantially increased (k = 1.5).

The reservations about the hypothetical nature and potential
irrelevance of parameter values in the example analyzing the increase
in efficiency (Table 1) also apply, of course, to the example dealing
with the effects of centralization (Table 2). However, this example
indicates that, if increasing returns scale are associated with the
payment system, cost savings can be achieved by centralizing the
system irrespective of the level of returns to scale.

3.3 Economies of Scope in the Production of Payment Services

The efficient organization of the production of payment services was analysed above on the assumption that the production of payment services can be examined separately as an activity involving one product. The production of payment services is largely carried out by banks as part of their business. Consequently, the assumption forming the basis for the above analysis is valid only if the production of payment services is separable in the bank's general production function. In practice, separability means that it would pay to organize the production of payment services and other banking activities into two completely separate firms, which, on a consolidated basis, would produce at least as much profit for their owners as integrated banking activities.

From the technical point of view, the optimal organization of banking activities can be analyzed as an issue of economies of scope in banking. As regards the production of payment services, the existence of economies of scope is associated with the properties of the cost function for these services. After Fama (1980), it is assumed for the sake of simplicity that banking business consists of financial intermediation (D) and the production of payment services (M). Let the cost function related to the former (if financial intermediation is carried out separately) be $c^D(D)$, the cost function related to the latter $c^M(M)$ and the cost function for integrated activities $c(M,D)$. The degree of economies of scope $Sc(M,D)$ can then be defined as follows

$$(21) \quad Sc(M,D) \equiv \frac{c^M(M) + c^D(D) - c(M,D)}{c(M,D)}$$

Economies of scope exist in banking if $Sc(M,D) > 0$.[8]

The existence of economies of scope in banking may be of importance in determining whether payment services should be produced by banks or

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[8]See Chapter 4 in Baumol-Pantzar-Willig (1982).

the public sector. In the institutional systems of many countries, it
is a general principle that the government sector does not participate,
at least to any great extent, in financial intermediation. If
significant economies of scope exist in banking as a whole, it does
not necessarily pay the public sector to produce payment services on a
large scale. Even though the production of payment services organized
separately as a private activity involved the inefficiency of a
natural monopoly, significant economies of scope might nevertheless
make the production of payment services as part of integrated banking
profitable for the economy as a whole.

In the following example, we examine how economies of scope in the
banking sector affect the production costs of payment services.

Banking consists of the production of payment services (M) and
financial services (D). Two factors of production, with prices p_1 and
p_2, are needed in production. The costs of banking can then be
described by means of the following translogarithmic cost function:

$$(22) \quad \ln C = \alpha_0 + \alpha_1 \ln M + \alpha_2 \ln D + \beta_1 \ln p_1 + \beta_2 \ln p_2$$

$$+ \frac{1}{2}\sigma_{11}(\ln M)^2 + \sigma_{12}\ln M \ln D + \frac{1}{2}\sigma_{22}(\ln D)^2$$

$$+ \frac{1}{2}\gamma_{11}(\ln p_1)^2 + \gamma_{12}\ln p_1 \ln p_2 + \frac{1}{2}\gamma_{22}(\ln p_2)^2$$

$$+ \delta_{11}\ln M \ln p_1 + \delta_{21}\ln D \ln p_1 + \delta_{12}\ln M \ln p_2 + \delta_{22}\ln D \ln p_2$$

This cost function can be thought of as an approximation for any
production technology. The homogeneousity and symmetry conditions
related to the cost function are as follows:

(23) $\beta_1 = 1 - \beta_2$ $\qquad$ $\delta_{11} = - \delta_{12}$ $\qquad$ $\gamma_{11} = - \gamma_{21}$

$\qquad\qquad\qquad\qquad\quad$ $\delta_{12} = - \delta_{22}$ $\qquad$ $\gamma_{22} = - \gamma_{12}$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad$ $\gamma_{21} = \gamma_{12}$

As in the previous section, it is assumed that increasing returns to scale are associated with the production of payment and financial services. In the case of equation (22) this assumption means that the following inequality holds true:

(24) $\dfrac{\partial \ln C}{\partial \ln M} + \dfrac{\partial \ln C}{\partial \ln D} = \alpha_1 + \alpha_2 + \sigma_{11} \ln M + \sigma_{12}(\ln M + \ln D) + \sigma_{22} \ln D < 1$

According to equation (24), if both services are increased by a certain amount production costs grow by relatively less with respect to this amount. If cost function (22) now also includes economies of scope, it means that the following inequality should hold true (see Murray and White, 1983):

(25) $\alpha_1 \alpha_2 < - \sigma_{12}$

where the parameters α_1 and α_2 are related to the separate cost effects of payment and financial services and the parameter σ_{12} to the combined cost effect of these services. If the homogeneity and symmetry conditions of cost function (22) are taken into account and it is assumed, for the sake of simplicity, that the levels of production of payment and financial services are equal ($D = M$), the cost function can be rewritten as follows:

(26) $\ln C = \alpha_0 + \beta_1 \ln p_1 + (1 - \beta_1) \ln p_2 - \dfrac{1}{2}\gamma_{12}(\ln p_1 - \ln p_2)^2$

$\qquad\qquad + (\alpha_1 + \alpha_2) \ln M + \dfrac{1}{2}(\sigma_{11} + \sigma_{12} + \sigma_{22})(\ln M)^2$

It can be seen from equation (26) that the possible existence of economies of scope affects costs mainly through the last two terms in the equation. Just how great the cost savings obtained through economies of scope are in relation to separate production depends on the values of the following parameters: α_1, α_2, σ_{11}, σ_{22} and σ_{12}. In particular, the larger the absolute value of the parameter σ_{12}, the larger are the cost savings associated with production under economies of scope.

Next, we use a simple example to examine how an increase in economies of scope affects the costs of the banking sector's production of services. In this example, it is necessary to fix the values of the parameters mentioned above. We first assume that there are no economies of scope in production and then compare this situation with one in which such economies of scope do exist. To start with, the values of parameters are assumed to be as follows:

(27) $\alpha_1 = 0.2$ $\sigma_{11} = 0.04$ $\sigma_{12} = -0.02$

$\alpha_2 = 0.1$ $\sigma_{22} = 0.03$

As in the example in the previous section, we assume that the value of the aggregate output of payment services in the economy amounts to FIM 5 billion and that the above values of the parameters include increasing returns to scale at this volume of output. However, inequality (25) does not hold true, so that the combined production of payment and financial services does not involve economies of scope according to the initial situation (27). If the absolute value of the parameter σ_{12} is raised from the value 0.02 received in initial situation, economies of scope are associated with the production technology. Table 3 shows what kind of cost savings are achieved compared with the initial situation if the parameter σ_{12} receives higher values than the original.

TABLE 3.   AN EXAMPLE OF THE COST SAVINGS ACHIEVED IN THE COMBINED
PRODUCTION OF PAYMENT SERVICES WHEN PRODUCTION INVOLVES
ECONOMIES OF SCOPE

σ_{12}	Costs in relation to the costs in the initial situation	Cost savings FIM mill.
- 0.02	1	0
- 0.022	0.92	160
- 0.024	0.84	320
- 0.026	0.76	480
- 0.028	0.70	600

It is assumed in Table 3 that the total costs of the production of
payment and financial services in the initial situation amount to FIM
2 billion. According to Table 3, a 10 per cent increase in the
absolute value of the parameter σ_{12} means an 8 per cent fall in costs
in the production of payment and financial services. However, these
cost savings seem to diminish slightly in line with the increase in
the values of the parameters. Nevertheless, the message in Table 3 is
clear: even fairly modest economies of scope may result in substantial
cost savings at the aggregate level, when the production of payment
and financial services is carried out by the same sector.

The above example is hypothetical and does not refer to any real
economy. It does, however, give some suggestions as to why, for example
in Finland, the production of payment services has traditionally been
combined with the production of financial services. Owing to the
deficiency of data, it is not possible at present to carry out an
empirical analysis of the suitability of cost function (22) for
describing the production of payment and financial services in the
Finnish economy. The existence of economies of scope is supported by
international empirical analyses with respect to the production of
financial services, see e.g. Murray and White (1980 or 1983).

3.4 Externalities and the Production of Payment Services

Certain externalities relate to the production of payment services. In the following, we examine first the inefficiency stemming from the administrative pricing of payment services and then that induced by the chain structure of the system. The existence of these sources of inefficiences means that the efficiency of the payment system can be enhanced by government regulation.

Considerable informational problems attach to the determination of prices of payment services, even when it takes place in the market. The costs of many transactions consist of both a fixed transactions cost component and a variable cost component dependent on the size of the transaction. In that case, the determination of the marginal cost of a single transaction and thereby of the price could be so costly that, so as to avoid information costs, market-determined prices would be standard prices.

In practice, standard prices for payment services are not generally determined in the market. This is mainly because the institution of money is controlled by the central government. The use of money for payments does not usually involve any cost for its user, since the institution of money is implemented as a public good, the costs of which to the economy are covered out of taxes and the seigniorage accruing to the central bank. Since economic agents can use money to make payments either free of charge or at low costs, private producers of payment services (mainly banks) have difficulties in selling their services at market prices. It has frequently been the case that private payment services have also been free services. Alternatively, they may have carried a cartel price agreed upon between banks, which has nevertheless mostly been below the market equilibrium price.

For private firms producing payment services, the unprofitability of payment services as a separate activity means that it is worth producing services at minimum costs. Hence, the administrative prices charged for services tend to reduce the inefficiency resulting from imperfect competition in the production of payment services. Losses

arising from the provision of payment services are covered by profits
arising from economies of scope in other activities.

On the other hand, the administrative pricing of payment services
results in a distortion in demand behaviour. Because the actual
volume in the market is determined by the level of demand
prevailing at the given administrative price, the distortion is
also reflected in the use of payment services. To observe the
effects of distortion, we assume that the demand for an arbitrary
payment service i depends inversely on its own price p_i and
directly on the prices of alternative payment services $p = p_1, p_2,$
..., $p_{i-1}, p_{i+1}...,$ p_n. Let the demand for payment services M_i^* at
the equilibrium prices p_i^*, p^* be

$$M_i^* = M_i(p_i^*, p^*)$$

If the equilibrium prices are lowered to the administrative level
$\bar{p}_i < p_i^*$, $\bar{p} < p^*$, the corresponding demand is

$$\bar{M}_i = M_i(\bar{p}_i, \bar{p})$$

It can be shown that if payment services are normal commodities as
understood in the theory of demand (the demand for them increases as
income rises), the demand for each service increases as equilibrium
prices are replaced by administrative prices as a result of a fall in
the price of each service. On the other hand, the increase in demand
is curbed by a simultaneous fall in the prices of alternative services.
In aggregate, the demand for payment services must increase, because
all administrative prices are lower than the market prices. By contrast,
in the case of certain individual services, the cross-substitution
effects can, in principle, exceed the total effect of the fall in the
service's own price, so that the demand for the respectice service
decreases. Viewed in terms of the market as a whole, the general
principle is that economic agents use an unnecessarily large amount of
payment services because of the subsidizing of prices. If the price
elasticities of the demand functions for different services with

respect to their own prices are of the same order of magnitude, their excess utilization is greatest in the case of services whose prices are most highly subsidized. These are likely to be the services which are expensive for the economy to produce in equilibrium.

There are two ways of dealing with the inefficiency caused by administrative pricing. First, inefficiency can be eliminated if the central bank abandons the principle of implementing the institution of money as a free good. This, however, requires that the market is able to price the services produced by the payment system efficiently. If this is not possible, the payment system has to be implemented as a public service. In that case, services can be produced either as public services proper or as privately produced public services.

A particularly significant source of inefficiency in the private production of payment services may arise from the fact that many payment services consist of a chain of transactions. The various transactions making up the chain often take place in different firms. A payment normally originates in, for example, the trade sector and then passes through the banking sector before finally reaching the recipient of the payment. The decisions made by each firm in the chain may exert a significant impact on the costs of the payment service activities of another firm in the chain. For instance, let us assume a situation where a central retail store is considering investing the sum I_K in a system of EFT POS terminals.

Similarly, a bank is planning to invest the sum Ip in a giro payments system. It is assumed that the real volume of payments maintains a constant level M. The rate of interest is assumed to be r. The investments result in cost savings in the production of payment services in both the store and the bank. It is assumed that the store's savings in real unit costs for one period amount to $c_K = c_K(I_K, I_p)$ and the corresponding savings of the bank to $c_p = c_p(I_K, I_p)$. Hence, the investments of the store and the bank are positive externalities for each other's cost functions. For the sake of simplicity, it is further assumed that capital does not wear out and the investment horizon is infinite.

If both the store and the bank decide upon their investments as
separate independent units, the optimization problems describing their
decision-making situation are as follows

(28a) $\max_{\{I_K\}} \pi_K = \frac{(1+r)}{r} c_K (I_K, I_P)M - I_K$

(28b) $\max_{\{I_P\}} \pi_P = \frac{(1+r)}{r} c_P (I_K, I_P)M - I_P$

Of key importance for the optimization problems is that both the store
and the bank take each other's investments as given and do not take
into account the cost-reducing effects of their own investments on the
unit costs of the other investor. The optimal investments are
determined by the first-order conditions

(29a) $\frac{(1+r)}{r} M \frac{\partial c_K}{\partial I_K} = 1$

(29b) $\frac{(1+r)}{r} M \frac{\partial c_P}{\partial I_P} = 1$

According to the conditions, the shop and the bank each set their
investment at a level at which an additional unit increase in outlays
results in a saving of corresponding size in their costs. If, by
contrast, one decision-making agent considers the store and the bank
as part of a group of firms and wishes to set the investments in the
payment system at a level which is optimal from the point of view of
the group, his decision-making problem is the following

(30) $\max_{\{I_K, I_P\}} \pi_c = (\frac{1+r}{r}) M [c_K(I_K, I_P) + c_P(I_K, I_P)] - I_K - I_P$

The profit function of the group includes the cost savings and
investment outlays of both the store and the bank. Unlike the previous

case the decision-making agent is now able to decide upon the sizes of
the investments to be implemented by both units. The optimal
investments are determined by the first-order conditions

$$(31a) \quad \left(\frac{1+r}{r}\right) M \left(\frac{\partial c_K}{\partial I_K} + \frac{\partial c_p}{\partial I_K}\right) = 1$$

$$(31b) \quad \left(\frac{1+r}{r}\right) M \left(\frac{\partial c_K}{\partial I_p} + \frac{\partial c_p}{\partial I_p}\right) = 1$$

If the optimality conditions of the group are compared with those of
the independent firms, it can be seen that in the group it would be
optimal for each firm to invest more than in the case where the firms
operate separately, since the partial derivatives $\partial c_p/\partial I_K$ and
$\partial c_K/\partial I_p$ are both positive.

In conclusion, we can note that it is difficult for independent
private firms to take into account the externalities resulting from
the formation of chains. If, however, the investments related to the
payment system were left to the public sector, it would, in principle,
be easy for it to internalize the externalities and hence increase the
cost savings accruing to the entire economy. It is particularly
difficult to take into account the externalities between private firms
when $\partial c_K/\partial I_p$ and $\partial c_p/\partial I_K$ are of very different size. In that case, one
of the firms benefits much more from the additional investments made
by the other firm than the latter does from the former firm's
investments. For the firm benefiting more to persuade the one
benefiting less to carry out the optimal additional investments, it
should make side payments to the latter. However, it has proved very
difficult to implement side payments in practical contexts.

Finally, we examine the externality which may arise when individual
firms producing banking and payment services (banks) are not necessarily
aware of the effect of their decisions on the payment system as a
whole. The stability of the entire payment system probably depends on
the safety and reliability of individual banks' own activities and

systems. If, for example, major disturbances appear in the electronic funds transfer system of one bank, customers may lose confidence in this bank. In an extreme case, this may be reflected in a run on the bank. Runs on banks may spread to other banks and jeopardize the entire payment and banking system. This may happen particularly when the market shares of individual banks are large. With the undermining or loss of confidence in the payment system, society is forced either to enhance the stability of the system by certain special measures (e.g. a deposit insurance scheme in the case of the fiat money system) or to replace the existing system with one which is more soundly based (e.g. a commodity money system established by the public sector). Neither of these alternatives can be implemented without social costs.

In economics, the situation described above is associated with the research on runs on banks. An important study in this field in recent years is that by Diamond-Dybvig (1983), whose model has been further developed by Postlewaite-Vives (1987). In the Diamond-Dybvig model, the basic problems mainly relate to the modelling of the bank run situation itself, the analysis of its real economic effects and research on policies aiming at eliminating bank runs. A bank run is one possible solution to the model and it occurs with a certain exogenous probability. We are not interested here is discussing these questions on such a comprehensive basis. Instead, in the following analysis, we focus on the question as to what kind of linkage may arise between the decision-making of one individual bank and the stability of the entire system. Using the terms of the Diamond-Dybvig model, we consider how the probability of a bank run depends on banks' decisions and how these decisions affect social welfare.

It is assumed that there are two banks in the economy each of which intermediates finance (D) and produces payment services (M). The market share of bank 1 in both activities is γ. In the aggregate economy, there is a probability $\lambda \varepsilon (0,1)$ that the public loses its confidence in the payment system and banking, i.e. that the public ceases to utilize the services of the banking system and banks fail. For the sake of simplicity, assume that bankruptcy does not entail other costs for banks apart from the loss of market-priced income.

Conversely, the probability that the payment system continues to function as before is $1-\lambda$, in which case banks receive the interest rate differential $r_L - r_D$ for the intermediation of finance and the price p_s for each unit of payment services provided.

The probability λ consists of two components. First, the payment system may break down completely because of an exogenous general crisis (e.g. war). Let the exogenous probability of a general crisis occurring be $\lambda_c \varepsilon (0,1)$. Secondly, the public may lose confidence in the payment system, if a sufficient number of erroneous transactions and disturbances of various kinds take place in the system. The number of errors and disturbances depends on how much banks invest in their technology and security. Let the banks' investments be I_1 and I_2, and the marginal cost of investments c. To take into account the effects of the banks' investments, we simply assume that the general convex probability $\lambda(I_1, I_2)$ describes the effects of investments on the risk of a collapse in the payment system. The properties of probability $\lambda(I_1, I_2)$ are:

$$\frac{\partial \lambda}{\partial I_i} (I_1, I_2) \leqslant 0; \qquad \frac{\partial^2 \lambda}{\partial I_i^2} (I_1, I_2) \geqslant 0; \qquad i = 1, 2$$

$$\lambda(I_1, I_2) \; \varepsilon \; [0, \, 1-\lambda_c]$$

$\lambda(I_1, I_2)$ is independent of probability λ_c.

From the independence property it follows that the overall probability is the sum of two components: $\lambda = \lambda(I_1, I_2) + \lambda_c$.

Although the breakdown of the payment system is a costless event for the banking sector (except for losses of profits), it is not for the economy as a whole. Society has to organize other techniques of payment and financial intermediation, which - if the prevalent institutional arrangement has been efficient - absorbs an increasing amount of the economy's resources. In practical terms, it means that the economy may have to introduce a fully-backed commodity money system or to create

an efficient deposit insurance system. We assume that the net cost function the economy faces as a result of the new payment system is of the form

$$C_s = c_D D + c_m M$$

$$c_D, c_m > 0$$

We next examine the decision-making problem of companies by assuming that they operate according to the principle of the maximization of expected profits and that the investments I_i are their decision variables. The expected profits of bank 1 are of the following form

$$(32) \quad E(\pi_1) = [\lambda(I_1, I_2) + \lambda_c][(r_L - r_D)\gamma D + p_s \gamma M] - cI_1$$

The maximization of expected profits requires that the following first-order condition holds true

$$(33) \quad \lambda_1[(r_L - r_D)\gamma D + p_s \gamma M] - c = D$$

$$\lambda_1 = \frac{\partial \lambda(I_1, I_2)}{\partial I_1}$$

The first-order condition of the optimization problem concerning bank 2 is respectively

$$(34) \quad \lambda_2[(r_L - r_D)(1 - \gamma)D + p_s(1 - \gamma)M] - c = D$$

$$\lambda_2 = \frac{\partial \lambda(I_1, I_2)}{\partial I_2}$$

We now examine the corresponding situation from the point of view of a decision-making agent maximizing social welfare. If, according to the assumption, the prices $r_L - r_D$ and p_s are efficient market prices they also reflect the social value of payment services and financial intermediation. Similarly, the investment cost c is also the relevant

opportunity cost from the point of view of the economy. Taking into account the additional cost C_s resulting from the breakdown of the payment system, the objective function of a social decision-making agent can be expressed as follows

$$(35) \quad E(\pi_E) = [\lambda(I_1, I_2) + \lambda_c][(r_L - r_D)D + p_s M] - c(I_1 + I_2)$$

$$- [1 - (\lambda(I_1, I_2) + \lambda_c)][c_D D + c_m M]$$

If the social decision-making agent is able to control the investments I_1 and I_2, he maximizes social welfare by setting the investments at the levels implicitly determined by the following conditions

$$(36a) \quad \lambda_1 \gamma[(r_L - r_D + c_D)D + (p_s + c_m)M] - c = 0$$

$$(36b) \quad \lambda_2(1 - \gamma)[(r_L - r_D + c_D)D + (p_s + c_m)M] - c = 0$$

It is obvious that the first-order conditions describing the optimal behaviour of the social decision-making agent imply larger investments in security and technology than would be optimal from the point of view of firms. This is due to the fact that the economy has to incur the costs resulting from a possible breakdown of the payment system. Banks avoid these costs, because in this model they cease all activities by going bankrupt. Although the decision-making situations of banks and society in the above model are highly asymmetric, the analysis may still be relevant from the point of view of real situations. The asymmetry of private and public interests was built into the model in a very straight/forward fashion mainly for the sake of simplicity. However, it is difficult to believe that, in practical situations, the private sector would take full account in its decision-making of all the social utilities of an existing and efficiently functioning institution. If there are some differences between interests, the banking system creates externalities for the payment system, and the entire payment system functions more sensitively to risk and disturbances than is advantageous from the point of view of the economy as a whole.

On the other hand, the exogenous risk intentionally included in the model constitutes a negative externality for the entire economy. Actions taken within the economy cannot be used to affect the magnitude of this risk. Nor can there be any difference between the public and private points of view in this respect. Society is nevertheless forced to bear this risk. As there is no way to include this risk in banks' decision-making, the bearing of it is probably a pure public disutility. In this context, the bearing of risk means the construction of an operational reserve system for situations in which this risk is realized.

On the basis of the foregoing analysis, it can be concluded that (perhaps particularly in systems employing sophisticated technology) banks may constitute a negative externality for the entire payment system. Banks may end up by investing too little from the point of view of the economy in technology and procedures supporting a system which is reliable and free of disturbances. This externality can be eliminated by, for example, the central government setting binding norms and standards for banks. By contrast, risks exogenous from the point of view of the entire economy cannot be controlled so that they can be taken into account in banks' decision-making. Rather reserve systems for times of crisis are best set up by the public sector.

3.5 Differences in Preferences

The relationship between preferences prevailing in the market and those of social decision-making agents is, of course, important in assessing the central bank's role in the payment system. Put simply, it can be stated that if these preferences do not coincide, the central bank must intervene in the functioning of the market for payment services. Differences may emerge between preferences, because, for instance, possibly "money votes" for the preferences prevailing in the market. This is because it is typical of preferences producing well-behaved aggregate demand that the preferences of individuals are weighted by their income and wealth levels. In that case, income and wealth distribution affects markets allocation if the preferences of economic agents differ from each other.

We do not analyze differences in preferences in any more detail here, because in principle their impact on the need for intervention is obvious. The question of the payment system as a national service system offers an example of a situation in connection with which differences in preferences may arise.

For the payment system to fulfill its function as a national service system in a satisfactory fashion, it should in principle, make its services available to all economic agents in the form of a network which is sufficiently dense and accessible to its users. A purely private system may not necesarily meet all these conditions. For example, it is possible that a private firm producing payment services discriminates against its less highly-rated customers more strongly than would be desirable from the point of view of a national system. Moreover, it is possible that society would prefer a denser service network in sparsely-populated or developing regions than would be set up by private companies behaving optimally. If the government desires a solution which deviates from that arising in the market, it should intervene in the functioning of markets, for example, by subsidizing prices or undertaking major investments.

3.6 Summary of the Points Relating to the Efficiency and Organization of the Payment System

According to the foregoing analysis the efficiency of the payment system depends, on the one hand, on whether the system is centralized or decentralized, and, on the other hand, on whether the system is operated entirely by the private sector or partly or entirely by the public sector.

The centralization of the payment system gives rise to cost savings for the economy as a whole whenever the production of payment services involves economies of scale. Since particularly electronic payment systems employing a high degree of data-processing technology involve substantial fixed costs, it can be assumed that economies of scale attach to their operation.

It is worth implementing a centralized payment system as a public
activity, if there is no effective threat in the market for payment
services of a potential market entrant forcing a private monopoly to
operate efficienctly from the macroeconomic point of view. The utility
that may be obtained by the nationalization of the payment system
diminishes or disappears completely if the production of payment
services gives rise to significant economies of scope as a result of
the production of payment services and financial intermediation being
carried out by the same organizations (banks). In that case, the
public sector can only produce payment services in the most efficient
way if it also starts to intermediate finance. However, the economies
of scope arising in the production of payment services and financial
intermediation may only be ostensible and based on the utilization of
float items.

The central bank should control the functioning and development of the
payment system by means of various guidelines, norms, economic
incentives and possibly its own investments. This is profitable for
the economy because several externalities are connected with the
functioning of the payment system. One externality arises from the
fact that the prices of payment services are not market prices.
Rather, they are usually lower than market prices. Consequently, the
market subsidizes payment services as a whole, resulting in inefficient
use of resources. The degree of subsidization is greatest in the case
of the methods of payment which are most expensive from the point of
view of the economy as a whole. Another externality is associated with
the fact that the payment system generally consists of a chain of
firms (e.g. store-bank-industrial company). Hence, the implementation
of investments designed to develop the system often gives rise to
disputes, because usually the firm making the investment bears the
cost whereas all the firms in the chain benefit therefrom. If no
agreement is reached on the distribution of costs and benefits, the
level of investment of the system easily remains too low. A third
externality may arise from the fact that, when banks estimate the
reliability and safety of payment systems they assess the costs
induced by possible disturbances mainly from the point of view of
their own operations. It is probable that banks do not adequately take

into account the fact that disturbances in the systems of individual banks affect economic agents' confidence in the functioning of the entire payment system. As a result, banks do not invest enough from the point of view of the economy as a whole in securing the reliability and safety of their systems.

IV REFORM OF THE PAYMENT SYSTEM AND MONETARY POLICY

1 Introduction

The central message of neoclassical macroeconomic theory is that in
long-run equilibrium the general price level in the economy is
determined by the quantity of money or liquidity. Real economic
variables are independent of the quantity of money. Hence in the long
run monetary policy is said to be neutral since it is based on the
control of the money stock.

A number of different views have been put forward concerning the
short-run effects of monetary policy. Some economists argue that
monetary policy is also neutral in the short run. The most recent
version of this essentially old idea is the real business cycle theory,
according to which cyclical variations in the economy are the result
of economic agents' optimal adjustment to disturbances appearing
mainly on the supply side.[1] However, most economists may be prepared
to accept the assertion that changes in the supply of money or the
rate of interest exert real economic effects in the short run. These
effects emerge through several propagation mechanisms, whose role
economists stress in different ways.

Nowadays, the propagation mechanisms usually applied in models are
based on differences in economic agents' information or on price and
wage rigidities in the economy.[2] If firms have imperfect information
on market prices or costs, they can make mistakes in interpreting
price and cost changes. For example, they may interpret a general
price change caused by monetary policy as a change in their own
profitability and, depending on the shock, either expand or contract
their activities. The central bank then has the opportunity to affect
cyclical variations by implementing surprise measures, if it has the
information advantage on its side. If prices in the economy are

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[1]See Blanchard (1987), McCallum (1986) and Eichenbaum-Singleton (1986).

[2]See Blanchard (1987) and McCallum (1986).

perfectly elastic, the opportunities for exerting influence are
temporary and they cannot be utilized through a systematic and
predictable policy. The incentive mechanism based on differences in
information has mainly been developed by Lucas and it is generally
taken into account in models by means of the Lucas supply function.[3]

If prices of commodities and inputs in the economy adjust sluggishly
towards their equilibrium levels, the central bank can also affect
economic conditions by pursuing systematic policies. If, for example,
wages adjust slowly, the central bank can increase the level of
economic activity by means of expansionary monetary policy, because a
rise in prices which is faster than that in wages improves the
profitability of the corporate sector. A similar incentive mechanism
also operates when prices of commodities or inputs (other than labour)
adjust gradually. Among the most important contributions to the
development of wage rigidity models have been Taylor (1980a, 1980b,
1986) and Fischer (1977); price rigidity models have been applied by
Blanchard (1983, 1987), among others.

Generally speaking, monetary policy affects the economy through the
demand for money (liquidity) function. Changes in monetary policy are
reflected through the money demand function directly or indirectly in
the interest rate level and the rate of inflation. These, in turn, may
affect aggregate supply and demand and, in conditions of an open
economy, capital movements, the current account and exchange rates.

The demand for money function changes as the payment system develops.
Thus, changes in the payment system either diminish or enlarge the
scope for monetary policy to influence the economy. In the following
sections, we first examine the direct impact of an improvement in the
payment system on the money demand function. We then briefly discuss
the effects of an improvement in payment techniques on the autonomy of
monetary policy in an open economy. Finally, we analyze some of the
effects which developments in the payment system may have on the
economy through monetary policy.

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[3]See Lucas (1972, 1973), Sargent - Wallace (1975), Barro (1978) and
Barro - Rush (1980).

In addition to the macroeconomic effects associated with the normal
development of the payment system, we investigate the adjustment of
the economy under two different money supply mechanisms. In the first
case the supply of money follows an exogenous stochastic process,
whereas in the second case the central bank regulates the supply of
money by seeking to even out fluctuations in the price level and/or in
the real economy. The money supply mechanisms are linked to payment
systems by the fact that the exogenous money supply mechanism
described above could emerge in a commodity money system implemented
by the private sector. Similarly, the money supply mechanism
controlled by the central bank is associated with the fiat money
system implemented by the public sector.

2   Development of the Payment System and the Demand for Money

Many economists consider that the demand for money still plays a very
significant role in the transmission of monetary policy effects to the
economy. Apart from directly regulating the supply of money or the
interest rate level, the government can affect the state of financial
markets, for example, through its own net borrowing or the control of
capital movements. However, of major importance as regards the
economic policy effects of all the intervention methods mentioned
above, is what kind of relationships prevail at any one time between
real activity in the economy, the price level and/or the rate of
inflation, the nominal interest rate and the demand for money.

Microeconomic models provide very diverse explanations for the demand
for money, as was seen in the essay dealing with the demand for money.
The links between the demand for money and the development of the
payment system can be presented in these models through changes in
transactions and adjustment costs. However, the demand for money
equations used in macroeconomic models are generally based either on
the equation derived from the neoclassical model or that based on the
cash-in-advance principle. Underlying both approaches is the view that
the key property of money is its perfect liquidity in effecting
transactions. No other form of wealth is as perfectly liquid as money,

so that it is an imperfect substitute for all other forms of wealth
and the demand for it does not fall to zero at any finite price level.
The demand equations based on these two approaches can be broadly
considered as belonging to the family of quantity theory models. In
macroeconomic models, the demand for money thus depends solely on the
nominal rate of interest and the value of transactions. The latter
quantity is generally described by means of nominal national income. A
typical demand for money equation in a macromodel is hence based on a
demand equation for real balances of the following type:

$$\frac{M}{p} = V(r)Y$$

Y = output
r = nominal rate of interest

The demand for money equation is normally used in macromodels in
log-linear (or constant-elasticity) form, in which case it is of the
following type:

$$m - p = \alpha_0 - \alpha_1 r + \alpha_2 y \qquad \alpha_i > 0$$

α_1 = interest rate elasticity of the demand for money
α_2 = real income elasticity of the demand for money
m, p, y are the logarithms of the quantity of money, the price level
and output.

A conventional empirical observation is that real income elasticity
α_2 is between a half and one in macromodels (see Judd-Scadding (1982)).
Dynamic analysis with uncertainty taken explicitly into account is
applied in many macroeconomic studies today. The constant elasticity
demand function corresponding to these assumptions is as follows:

$$m_t - p_t = \alpha_0 - \alpha_1 r_t + \alpha_2 y_t + \epsilon_t \qquad \alpha_0, \alpha_1, \alpha_2 > 0$$

$$\epsilon_t = \text{disturbance term } E\epsilon_t = 0, \text{ Var } \epsilon_t^2 = \sigma_\epsilon$$

$\epsilon_{t \pm i}$ are i.i.d. random variables; i = 0, 1, 2,...

If one wants to get some idea of the effects on the demand for money of developments in the payment system, the extended portfolio model with transactions costs analyzed in Section 2.2.2 of the second essay provides a good benchmark case. In that model, the demand for money falls when the transactions costs of the alternatives to money fall relative to those of money. For the same reason, the interest elasticity of the demand for money rises.

Empirically, it appears quite plausible to associate the relative cheapening of transactions carried out using the alternatives to money and improvements in the efficiency of the payment system with each other. Based on this view, we state the following hypothesis on the relationship between the parameters of the money demand function and the state of efficiency in the payment system:

> Hypothesis: Let $S = \{s\}$; $s \epsilon R^t$, be the set of measures describing the payment system. Then (i) $\alpha_0(S)$ is a decreasing function of S, i.e. $\alpha_0'(S) \leq 0$ (ii) $\alpha_1(S)$ is an increasing function of S, i.e. $\alpha_1'(S) \geq 0$.

The hypothesis states first that the "autonomous" demand for money decreases as the payment system develops. It was pointed out in Section 3.3 of the second essay that empirically this effect may be hard to distinguish from the income effect proper if the technical improvements in the payment system are associated with general economic growth. In standard regressions with only interest rates and real income explaining the demand for money this would imply that the income elasticity of the demand for money would fall along with technical developments. Secondly, the hypothesis states that the interest rate sensitivity of the demand for money rises with improvements in the efficiency of the payment system.

3 The Development of the Payment System, Capital Movements
   and the Autonomy of Monetary Policy

A factor limiting the scope for the pursuit of monetary policy is how
easily economic agents are able to adjust to changes in monetary
policy. The interest rate elasticity of the demand for money is one
manifestation of the opportunities for adjustment. In an open economy,
considerable scope for adjustment arises through international
financial and capital markets. The importance of international markets
for domestic financial markets depends on how frictionlessly economic
agents are able to operate in different markets. An extreme case is
that where domestic autonomous monetary policy becomes perfectly
neutral. This situation may arise if the domestic exchange rate (or
exchange rate index) is kept fixed and there are no restrictions on
capital movements. If, for example, an international bank or banking
group were then to provide domestic economic agents with an unlimited
facility to deposit or borrow overnight in a currency or currency
basket determining the exchange rate at a certain rate of interest,
the domestic central bank would be forced to apply the same rate of
interest. In this case - the standard Mundell - Fleming polar case -
the central bank has no chance of pursuing intervention policy aimed
at separate domestic objectives.

Though market conditions are hardly ever such that they favour the
emergence of the extreme situation described above; there are
differences in the degrees of monetary policy autonomy owing, among
other things, to risks prevailing in the market adjustment costs and
the regulation of capital movements. In the present context it is of
special interest to know to what extent the development of the payment
system affects the autonomy of monetary policy. The issue is examined
in a simplified flow-of-funds framework in which only pure financial
market factors are taken into account.

It is assumed that there are three sectors in the economy. The private
(non-bank) and government sectors together constitute the sector
referred to as the public. Banks and the central bank are dealt with
as separate sectors. The public's savings S and investments I are

assumed to be given. Savings can be allocated among money (C), domestic deposits (D) and foreign deposits (D*). Investments can be financed either with domestic (L) or foreign loans (L*). The allocation of funds among different investments depends on the deposit rate r_D and the world market rate r_f (the exchange rate is assumed fixed) in accordance with the following functions:

$$C = (h_c - \beta_c r_D - \gamma_c r_f)S$$

$$D = (h_D + \beta_D r_D - \gamma_D r_f)S$$

$$D* = S - C - D$$

$$h_i, \beta_i, \gamma_i > 0; \; i = C, D$$

The demand for loans depends on the lending rate r_L and the world market rate r_f as follows:

$$L = (\delta_0 + \delta_1(r_f - r_L))I$$

$$L* = I - L$$

$$\delta_0, \delta_1 > 0$$

Banks accept deposits and grant loans to the public. In addition, banks finance their activities with credit from abroad (F_B) at the rate of interest r_f and from the central bank (M) at the rate of interest r_m and invest abroad (F_L) at the rate of interest r_f and in cash reserve deposits with the central bank (CRD) at the rate of interest r_C. The banking sector's balance sheet is thus

$$D + M + F_B = L + F_L + CDR$$

It is assumed that capital movements involve frictions, in which case banks' net inflows of capital depend on the interest rate differential $r_m - r_f$ in the following way

$$F_B - F_L = \theta (r_m - r_f) \quad \theta > 0$$

The central bank collects cash reserve deposits from banks, issues notes and finances banks by granting them an unrestricted borrowing and deposit facility at the rate r_m. The central bank balances its balance sheet by adjusting its foreign exchange reserves (V). Hence, the balance sheet of the central bank is as follows

$$C + CRD + V = C + M$$

Assuming that the central bank collects c per cent of banks' domestic deposits in the form of cash reserve deposits and taking into account the banks' balance sheet, the central bank's balance sheet obtains the following forms

$$C + cD + V = C + L - D + FL - FB + cD$$

$$<=>$$

$$V = L - D + F_L - F_B$$

The latter form reveals that a change in the central bank's foreign exchange reserves is equivalent to the sum of banks' domestic net lending and foreign net investments.

Banks' activities are examined in terms of a cartel, which, for the sake of simplicity, maximizes the cartel's monopoly profits. The profit function of the bank cartel is as follows

$$\pi_p = r_L L + r_c cD - r_D D - r_f(F_B - F_L) - r_m M$$

$$= (r_L - r_m)[\delta_0 + \delta_1(r_f - r_m)]I - [(r_D - r_m) - c(r_c - r_m)]$$

$$[h_D + \beta_D r_D - \gamma_D r_f]S - (r_f - r_m)\theta(r_m - r_f)$$

The bank cartel takes the rates of interest r_f, r_m and r_c as given and sets loan and deposit rates so as to maximize the cartel's profits. Optimal lending and deposit rates are

$$\tilde{r}_L = \frac{\delta_0}{2\delta_1} + \frac{1}{2}(r_f + r_m)$$

$$\tilde{r}_D = -\frac{h_D}{2\beta_D} + \frac{\gamma_D r_f}{2\beta_D} + \frac{1}{2}[r_m + c(r_c - r_m)]$$

When the optimal interest rates are inserted in the demand equations for lending and investment, the demand equations corresponding to financial market equilibrium are

$$\tilde{L} = \frac{1}{2}[\delta_0 + \delta_1(r_f - r_m)]$$

$$\tilde{D} = \frac{1}{2}[h_D + \beta_D(r_m + c(r_c - r_m)) - \gamma_D r_f]S$$

$$\tilde{C} = \frac{1}{2}[\tilde{h}_c - \beta_c(r_m + c(r_c - r_m)) - \tilde{\gamma}_c r_f]S$$

$$\tilde{D}^* = S - \tilde{D} - \tilde{C}$$

$$\tilde{h}_c = 2h_c + \frac{\beta_c h_D}{\beta_D}$$

$$\tilde{\gamma}_c = 2\gamma_c + \frac{\beta_c \gamma_D}{\beta_D}$$

If desired, other financial items in the economy can be calculated utilizing balance sheet identities and the equation for banks' capital movements. The equilibrium demand functions indicate that a rise in the market rate r_m leads to a reduction in domestic loans and an increase in foreign loans and domestic deposits, whereas it results in a fall in cash holdings and (probably although not certainly) in foreign deposits. A rise in foreign rates of interest has qualitatively the same effect but in the opposite direction. A rise in the rate of

interest on cash reserve deposits results in an increase in deposits and a reduction in cash holdings and (probably although not certainly) in foreign deposits.

The development of the payment system affects the economy described by the model by changing the parameters of the demand functions. In the previous section, the hypothesis was put forward that an improvement in the payment system reduces the autonomous level of the demand for money and increases its interest rate sensitivity. This hypothesis is applied to the model presented here by specifying the following relationships between the parameters and the state of the payment system (s):

$$h_c = h_c(s) \atop - \qquad\qquad \beta_c = \beta_c(s) \atop + \qquad\qquad \gamma_c = \gamma_c(s) \atop +$$

$$h_D = h_D(s) \atop + \qquad\qquad \beta_D = \beta_D(s) \atop + \qquad\qquad \gamma_D = \gamma_D(s) \atop +$$

According to the assumption, the interest rate sensitivity of the partial demand for money also increases with regard to the foreign rate of interest as the payment system becomes more efficient. From this assumption it follows that the autonomous demand for deposits grows as a result of an improvement in the payment system. The interest rate sensitivity of deposits also increases with regard to both interest rates.

We first examine changes in deposits, cash and foreign deposits as the payment system becomes more efficient but other factors remain unchanged. The partial derivative of deposits with regard to s is of the form

$$\frac{\partial \tilde{D}}{\partial s} = \frac{1}{2} \left[h_D^s + \beta_D^s(r_m - c(r_m - r_c)) - \gamma_D^s r_f \right] s$$

$$h_D^s = \frac{\partial h_D}{\partial s} \qquad\qquad \beta_D^s = \frac{\partial \beta_D}{\partial s} \qquad\qquad \gamma_D^s = \frac{\partial \gamma_D}{\partial s}$$

The following condition for the sign of the change in deposits is obtained:

$$\frac{\partial \tilde{D}}{\partial s} \begin{cases} > 0 \text{ when } r_m - c(r_m - r_c) > \dfrac{\gamma_D^s r_f}{\beta_D^s} - \dfrac{h_D^s}{\beta_D^s} \\[3em] < 0 \text{ when } r_m - c(r_m - r_c) < \dfrac{\gamma_D^s r_f}{\beta_D^s} - \dfrac{h_D^s}{\beta_D^s} \end{cases}$$

The partial derivative of cash with regard to s is

$$\frac{\partial \tilde{C}}{\partial s} = \frac{1}{2} \left[\tilde{h}_C^s - \beta_C^s(r_m - c(r_m - r_c)) - \tilde{\gamma}_C^s r_f \right] S$$

The sign of the partial derivative is determined by the following conditions

$$\frac{\partial \tilde{C}}{\partial s} \begin{cases} > 0 \text{ if } r_m - c(r_m - r_c) < \dfrac{\tilde{h}_C^s}{\beta_C^s} - \dfrac{\tilde{\gamma}_C^s}{\beta_C^s} r_f \\[3em] < 0 \text{ if } r_m - c(r_m - r_c) > \dfrac{\tilde{h}_C^s}{\beta_C^s} - \dfrac{\tilde{\gamma}_C^s}{\beta_C^s} r_f \end{cases}$$

Since the foreign deposits of the public are determined as a residual in the model, the following expression is obtained directly as their partial derivative with regard to s

$$\frac{\partial \tilde{D}^*}{\partial s} = - \frac{\partial \tilde{D}}{\partial s} - \frac{\partial \tilde{C}}{\partial s}$$

Accordingly, the sign of the change in foreign deposits depends on the signs and magnitudes of the changes in domestic deposits and cash.

The most obvious outcome of the above analysis would be that investment alternatives were gross substitutes for each other in market equilibrium. This would imply that, even in equilibrium, a more efficient payment system would result in a reduction in cash holdings and an increase in foreign deposits. However, the conditions for the signs of the partial derivatives reveal the property of demand behaviour in general equilibrium that gross substitution is only one theoretical possibility. An increase in the variable s describing the efficiency of the payment system could, for example, lead to a fall in the deposit rate by increasing the supply of deposits. This, in turn, would cause a rise in the demand for cash, so that the net impact may even be an increase in the demand for cash. If, in the previous example, there was gross substitution between money and deposits, the demand for foreign deposits could still decline. This would be the case if the increase in domestic deposits were larger in absolute terms than the decline in the demand for cash.

The gross substitution of investment alternatives also turns out to be a fairly critical property of demand behaviour with respect to the way in which the development of the system affects the autonomy of monetary policy in the traditional sense. To demonstrate this, we conclude this section by analyzing changes in the demand for different items with regard to changes in exogenous interest rates. The relevant partial derivatives are

$$\frac{\partial \tilde{D}}{\partial r_m} = \frac{1}{Z}\, \beta_D (1-c) S$$

$$\frac{\partial \tilde{D}}{\partial r_s} = \frac{1}{Z}\, \beta_D c S$$

$$\frac{\partial \tilde{D}}{\partial r_f} = -\frac{1}{Z}\, \gamma_D S$$

$$\frac{\partial \tilde{C}}{\partial r_m} = -\frac{1}{Z}\, \beta_c (1-c) S$$

$$\frac{\partial \tilde{C}}{\partial r_c} = -\frac{1}{2}\,\beta_c CS$$

$$\frac{\partial \tilde{C}}{\partial r_f} = -\frac{1}{2}\,\tilde{\gamma}_c S$$

$$\frac{\partial \tilde{D}^*}{\partial r_m} = \frac{1}{2}\,(\beta_c - \beta_D)(1-c)S$$

$$\frac{\partial \tilde{D}^*}{\partial r_c} = \frac{1}{2}\,(\beta_c - \beta_D)cS$$

$$\frac{\partial \tilde{D}^*}{\partial r_f} = \frac{1}{2}\,(\tilde{\gamma}_c - \gamma_D)S$$

The changes in deposits and cash as a consequence of changes in interest rates are quite uncontroversial and consistent. Rises in the market rate and the rate on cash reserve deposits increase deposits, because they raise the deposit rate. By contrast, a rise in foreign interest rates reduces deposits because it increases the return on the alternative. A rise in all interest rates reduces cash holdings. Changes in foreign deposits are determined by the net changes in domestic deposits and cash. Changes can be said to be plausible a priori if a rise in the market rate and in the rate on cash reserve deposits reduces foreign deposits and if a rise in foreign interest rates increases them. The latter effect always holds. However, for the former effects to hold in the present model it is necessary that the interest rate sensitivity of domestic deposits with regard to the deposit rate r_D is greater than that of cash. This depends on an assumption being made to this effect. From the point of view of demand behaviour, the making of this assumption means that the investment alternatives are presumed to be gross substitutes for each other (with respect to interest rates).

With the development of the payment system, the interest rate sensitivity of domestic deposits and cash increases with regard to all interest rates. Similarly, the interest rate sensitivity of foreign

deposits increases with regard to world market rates. By contrast, the effects important from the point of view of the autonomy of monetary policy - the impact of the development of the system on the sensitivity of foreign deposits to changes in the cash reserve deposit rate and the market rate - are ambiguous, even with respect to the sign. It can be claimed that the development of the system increases the leakage of monetary policy if the interet rate sensitivities of deposits with regard to the above interest rates are greater than the interest rate sensitivity of cash and increase by more than the latter in line with technical progress. This seems a very far-reaching claim. However, it is fulfilled in a very natural way when the basic assumption $\beta_D > \beta_C$ holds and both increase at a constant rate as a result of the technical development of the payment system. Closer analysis of this statement would require the dynamization of the model, which is not, however, done here.

As a conclusion to the foregoing analysis it can be stated that if the gross substitute relation between investment alternatives commonly required in financial market models prevails, the leakage of monetary policy increases with the development of the payment system.[4] Hence, the development of the system weakens the autonomy of monetary policy in the traditional sense. The foregoing analysis is seemingly very concise, since it is based merely on the analysis of exogenous saving. It would be easy to extend the analysis to include the banking sector's net capital imports and even its lending. The former strengthen the above results unambiguously while the effects of the latter would involve ambiguity problems similar to those in the analysis of deposits.

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[4]Thus, given the condition referred to above, the development of the payment system under conditions of an open economy has the same kind of effects as, on the one hand, increased currency substitution and, on the other hand, liberalization of capital flows; see Cuddington (1982) and Branson (1979).

4 The Effects of Monetary Policy under Conditions of a Developing Payment System

The effects of monetary policy on macroeconomic developments change as the payment system develops, because - as was pointed out in the previous sections - the demand for money function changes as the system develops. Analysis of monetary policy calls for the construction and analysis of a macromodel of the entire economy. In this section, a simple aggregate model of a closed economy is developed in which the demand for money function plays a dominant role. The model is used to examine the effects of monetary policy on the rate of inflation and the real growth path as well as changes in the effects as the payment system develops.

The effects of policy are studied under various assumptions on the adjustment of prices and wages. In addition, we examine a case where, because of information problems, the supply side of the economy behaves in accordance with the Lucas supply function. We also demonstrate that the pursuit of active monetary policy can produce a time path of the economy which, from the welfare point of view, is inferior to a fully exogenous policy rule. The latter money supply mechanism may be associated with, for example, a commodity money system established by the private sector.

It would be interesting to extend the analysis to cover open economy conditions, in which case changes in either the exchange rate or the foreign exchange reserves would - depending on the exchange rate regime - change the domestic effects of the development of the payment system as compared with the situation of a closed economy. These effects could be expected to weaken in an open economy, because the economy would contain another adjusting variable. However, the extension of the model to conditions of an open economy would (if the adjustment of the exchange rate or the foreign exchange reserves did not take place immediately) induce considerable technical problems, and so it is not attempted here.

4.1 Money and Prices

Monetary policy affects the time path of real aggregates primarily through the price mechanism. A change in the supply of money or the level of interest rates affects either the general price level or relative prices or both. In addition, monetary policy measures affect economic agents' expectations about the variables concerned. Changes in actual prices caused by monetary policy measures and in economic agents' expectations concerning these may induce economic agents to take decisions which are reflected in the time paths of real aggregates - output, investment and employment.

The demand for money is the major factor determining the price effects of monetary policy. We assume that the demand for money is determined in the model in accordance with the constant elasticity demand function presented in Section 2. The demand for money function in the economy is then as follows

$$(1) \quad m_t^d - p_t = \alpha_0 - \alpha_1 r_t + \alpha_2 y_t + \varepsilon_t$$

where m_t^d = logarithm of the demand for money in period t

p_t = logarithm of the price level in period t

r_t = nominal interest rate of an alternative asset in period t

y_t = the logarithm of output in period t

$(\alpha_0, \alpha_1, \alpha_2) > 0$, constant parameters

ε_t = i.i.d. disturbance term; $E_t(\varepsilon_t) = 0$, $Var(\varepsilon_t) = \sigma_\varepsilon^2$

In the demand for money function, output y_t is for the present treated as an exogenous variable. In order to be able to close the basic money market model presented here, we also need the relationships determining the formation of the interest rate and monetary policy. The interest rate is assumed to be determined according to the Fisher identity, so that the nominal interest rate r_t exceeds the anticipated real rate $\hat{r}_t^n$ by the amount of the rate of inflation $\hat{\pi}_t$. The real interest rate is assumed to be exogenous, so that the interest rate equation can be written in the form

(2) $r_t = \hat{r}^n_t + \hat{\pi}_t$

$\hat{\pi}_t = E \pi_t = E_t p_{t+1} - p_t$

$\hat{r}^n_t = E_t r^n_t$

This is an assumption which - strictly speaking - holds true only in the long term and on the condition that investors are risk-neutral. In the short term, a complex dynamic link exists in the markets between the nominal interest rate, the rate of inflation and the exogenous "natural" real interest rate.[5] However, it is not possible to take short-term dynamics into account in the present context as the model would then become too complicated in the technical sense.

If we assume that the exogenous real interest rate is determined by an exogenous Hicks-neutral growth process in the economy and the logarithm of the growth factor is denoted by s_t, equation (2) can be written in terms of the logarithms of the market price of the alternative asset, the real growth factor and the general price level in the following way

(2') $Eq_{t+1} - q_t = Es_{t+1} - s_t + Ep_{t+1} - p_t$

   q_t = logarithm of the market price of the alternative asset

As regards monetary policy, it is assumed that the central bank endeavours to regulate the quantity of money in the economy, in which case the nominal interest rate in the market and the rate of inflation are determined endogenously in the model. The policy rule can be presented formally in the following form:

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[5]An interesting international (8 OECD countries) comparison of the validity of the Fisher parity using data from different countries is presented in a study by Virén (1987). According to the tests carried out, the Fisher parity was not valid in the long term for any of the countries compared, though its validity increased in the last years of the period examined (1961 - 1987).

(3) $m_t^s = \bar{m}_t$

$\bar{m}_t$ = target level for the quantity of money in period t

The endogenous variables of the basic model can be solved when the policy rule is known. In the case of the policy rule (3), the expected time paths of the general price level and the nominal interest rate are as follows:

(4) $\hat{p}_t = \dfrac{1}{(1 - \dfrac{\alpha_1}{1+\alpha_1} L^{-1})} \dfrac{1}{(1+\alpha_1)} \left[\hat{\bar{m}}_t - \alpha_0 + \alpha_1 \hat{r}_t^n - \alpha_2 \hat{y}_t \right]$

(5) $\hat{r}_t = \hat{r}_t^n + \dfrac{1}{(1 - \dfrac{\alpha_1}{1+\alpha_1} L^{-1})} \dfrac{1}{(1+\alpha_1)} \left[\bar{m}_{t+1} - \bar{m}_t + \alpha_1 (\hat{r}_{t+I}^n \quad \hat{r}_t^n \right.$

$\left. - \alpha_2 (\hat{y}_{t+1} - \hat{y}_t) \right]$

$L^{-1}: L^{-1}(x_t) = x_{t+1}$

According to equation (4), an expected rise in the supply of money and the real interest rate raises the price level, whereas an expected increase in output lowers it. By contrast, according to equation (5), these same factors have a similar effect on the nominal interest rate. If the combined impact of monetary policy, the real interest rate and output is stabilized at either some constant level or on a time path changing at a constant rate, the following steady-state (p_{ss}) and trend solutions (Δ_{PT}) are obtained for the price level and the rate of inflation, respectively.

(6) $p_{ss} = -\alpha_0 + \bar{m}_{ss} + \alpha_1 r_{ss}^n - \alpha_2 y_{ss}$

(7) $\qquad \Delta p_T = \Delta \bar{m}_T + \alpha_1 \Delta r_T^n - \alpha_2 \Delta y_T$

According to the basic model, a permanent increase in the supply of money (an increase in the growth rate of the quantity of money) by one percentage point results in a corresponding rise (acceleration of inflation) of one percentage point in the price level.

To summarize the basic model it can be stated that if the money market reaches equilibrium in the fashion described in this model separately from other markets, monetary policy can only affect the rate of inflation. The direction of the effect is unambiguous: an easing of monetary policy, i.e. an increase in the quantity of money, raises the price level.

The effects of advances in the payment system in the model can be analyzed either as permanent effects or temporary ones. The state-steady solution (6) indicates that the development of the payment system leads to a rise in the steady-state price level through a decline in the parameter α_0 and an increase in the parameter α_1. Similarly, the development of the payment system results in an acceleration of trend inflation. However, neither of these effects are related as such to monetary policy (because the coefficients of $\bar{m}_{ss}$ and $\Delta \bar{m}_T = 1$). Rather they are due to the nature of the demand for money function. By contrast, in the short term it can be stated that the development of the payment system changes the effects of monetary policy. According to equation (4) an injection of money $\bar{m}_{t+i}$ expected to occur, for example, after i periods (i = 0, 1, 2, ...), raises the price level in period t in the following way (assuming that $\bar{\bar{m}}_{t+j} = 0 \ \forall \ j \neq i$):

(8) $\quad \hat{p}_t = \frac{1}{(1+\alpha_1)} \left(\frac{\alpha_1}{1+\alpha_1}\right)^i \bar{\hat{m}}_{t+i}$

Enhancing the efficiency of the payment system changes the price effects of the supply of money in the following way

$$\frac{\partial^2 \hat{p}_t}{\partial \bar{m}_{t+i} \partial \alpha_1} = \frac{1}{(1+\alpha_1)^3} \left[\frac{(i-\alpha_1)}{(1+\alpha_1)^{i-1}} \right]$$

According to the expression for the cross derivative, the price effect of the supply of money can either strengthen or weaken. The effect may weaken when the interest rate elasticity of the demand for money α_1 is high (the system is efficient) and the supply shock takes place fairly soon in the future (i is small). In other cases, the effect is strengthened.

4.2 Money, Prices and Real Aggregates

We next extend the model by incorporating a simple real sector of a (closed) economy. It is assumed that supply in the economy is determined according to a production process of the Cobb-Douglas type, where the substitution elasticity between inputs (labour and capital) is 1 and growth is treated as exogenous. For the sake of simplicity, the capital stock and labour are assumed to be constant, so that technical progress is the only source of growth in the model. If it is also assumed that firms have perfect information on prices and wages in period t and the adjustment of output does not involve adjustment costs, the logarithm of output can be expressed in the following form

(9) $y_t = a_0 + s_t + p_t - \gamma q_t - (1-\gamma)h_t$

$\quad\quad = a_0 - \gamma(q_t - s_t - p_t) - (1-\gamma)(h_t - s_t - p_t)$

q_t = logarithm of the nominal market price of capital

h_t = logarithm of the nominal wage

$\gamma \; \epsilon \; (0,1)$ = constant

$a_0 > 0 \quad$ = constant

According to equation (9), output depends inversely on the real wage and the real user cost of capital. For the sake of clarity, it may be

worth noting that, owing to the assumptions underlying the production functions, the following properties are valid in the model between the rate of growth of productivity $s_t - s_{t-1}$ and the real interest rate and the real wage

(10a) $s_t - s_{t-1} = r^n_{t-1} = $ real interest rate

(10b) $s_t - s_{t-1} = h_t - h_{t-1} - (p_t - p_{t-1}) = $ rate of growth of the real wage

To facilitate further analysis, it may be useful at this juncture to briefly present the equations of the basic model describing the aggregate economy. The following basic equations illustrate the functioning of the economy

(11) $y_t = a_0 - \gamma(q_t - s_t - p_t) - (1-\gamma)(h_t - s_t - p_t)$

(12) $m^d_t - p_t = \alpha_0 - \alpha_1 r_t + \alpha_2 y_t + \varepsilon_t$

To complement the production function and the money demand function we need relationships determining monetary policy and the formation of prices, wages and interest rates. The monetary policy rule is still of the form:

(13) $m^S_t = \bar{m}_t$

As regards price formation, it is assumed in the basic situation that all prices adjust completely flexibly and that the real wage and the real price of capital are always equal to their marginal productivities. These assumptions imply the following equations for the wage rate and the price of capital

(14) $h_t = s_t + p_t$

(15) $q_t = s_t + p_t$

The basic model (11) - (15) determines production, the price level, the
interest rate and the wage rate in the economy. Growth of productivity
and monetary policy are the main exogenous factors in the model and
the solutions of endogenous variables are shown in terms of these.

It can easily be seen from the basic model that the flexibility of
prices and the determination of wages and capital costs imply directly
the separation of real and money markets. If equations (14) and
(15) are inserted in equation (11), it can be seen that $y_t = a_0$ at all
price levels and for all growth paths of productivity. Monetary policy
does not affect the time path of production in any way. Rather, the
effectgs of monetary policy are confined to the money market. Since
the money market is fully separated from the real economy, the time
paths of the price level and the nominal interest rate necessary for
equilibrium in the money market are determined according to (4) and (5).

The assumptions of flexible prices, frictionless adjustment, homogeneous
agents and equally perfect information lead to the separation of real
and money markets and hence to the neutrality of monetary policy in
the model. In theory, a change in any of the above assumptions results
in the formation of linkages between the blocks of the economy and
thereby in the emergence of real monetary policy effects. As pointed
out in the introduction, in recent macroeconomic research the
assumptions have been changed in two respects, in particular. On the
one hand, the possibility has been investigated that economic agents
- notably firms - have imperfect information on market prices, as a
result of which they occasionally make mistakes when deciding on their
output. On the other hand, research has started out from the practical
observation that contracts are made in the economy on many prices,
which results in these prices being rigid at least for a while. Thus
prices are not perfectly flexible. In particular, it has been
considered obvious that at least nominal wages adjust sluggishly on
account of various collective agreements.

4.2.1 The Lucas Supply Function and the Effects of Policy

We first examine the adjustment of the economy when aggregate supply is determined in the basic model through the Lucas supply function. In the present basic model, the supply function is slightly more general than a typical Lucas supply function, so that the surprises are general profitability shocks, stemming from productivity, the price level or input prices. The Lucas supply function of the basic model can be written in the form

$$(16) \quad y_t - \hat{y}_t = -\gamma \left[b_q(q_t - \hat{q}_t) - b_s(s_t - \hat{s}_t) - b_p(p_t - \hat{p}_t) \right]$$

$$- (1-\gamma) \left[b_h(h_t - \hat{h}_t) - b_s(s_t - \hat{s}_t) - b_p(p_t - \hat{p}_t) \right]$$

$$b_i > 0, \quad i = q, s, p, h$$

According to equation (16), total supply rises from its expected level $\hat{y}_t$ if firms observe in period t that actual input prices are lower than those generally expected ($q_t - \hat{q}_t < 0$; $h_t - \hat{h}_t < 0$) or productivity or the general price level are above their generally expected levels ($s_t - \hat{s}_t > 0$, $p_t - \hat{p}_t > 0$). The coefficients b_1 illustrate the reactions of firms to surprise rise in the price level, productivity and input costs.

The reason why supply reacts even when all prices are perfectly flexible is that private agents incorrectly interpret fluctuations in prices and productivity. When an individual firm observes, for example, that the productivity of its own activities or its sales rise, or its costs of production fall, it interprets part of the changes as being associated solely with its own activities. Accordingly, it believes that these changes induce a greater change in its own profitability than in that of firms in general, and either expands or reduces its operations. In equation (16) it is assumed that firms may be mistaken in different ways with respect to the signals received from the markets, in which case generally $b_q \neq b_h \neq b_s \neq b_p$. In this context, it is worth mentioning that in the standard Lucas supply function it is assumed that $b_q = b_h = b_s = 0$ and that $b_p > 0$.

The extended model of the economy consists of equations (12) demand for money), (16) (aggregate supply) and (13) (supply of money). Equations (14) and (15) are also valid in the markets. It is assumed that the only exogenous shocks to the economy originate from changes in productivity. Hence the growth factor s_t follows the following process

(17) $s_t = s_{t-1} + \theta_t$

θ_t = surprise growth shock, $E\theta_t = 0$, $\text{Var } \theta_t = \sigma_s^2$,

θ_t i.i.d. $\forall$ t

If the central bank pursues a policy of regulating the supply of money as defined in equation (13), the functioning of the economy can be characterized by means of the following pair of equations:

(18) $y_t - \hat{y}_t = -\gamma[b_q(q_t - \hat{q}_t) - b_s(s_t - \hat{s}_t) - b_p(p_t - \hat{p}_t)]$

$-(1-\gamma)\{b_h(h_t - \hat{h}_t) - b_s(s_t - \hat{s}_t) - b_p(p_t - \hat{p}_t)]$

(19) $p_t - \hat{p}_t = \frac{1}{(1+\alpha_1)} \left[(\hat{\bar{m}}_t - \bar{m}_t) + \alpha_1(r_t^n - \hat{r}_t^n) - \alpha_2(y_t - \hat{y}_t) \right]$

$- \frac{1}{1+\alpha_1} \varepsilon_t$

According to equation (18), firm's mistakes in interpreting information result in production deviating from its trend path, i.e. real cyclical fluctuations. One source of errors is general price formation, which is determined according to equation (19). Price formation is affected by surprises in the supply of money and the real rate of interest and by unexpected variations in production. Hence, equations (18) and (19) form a simultaneous system of equations, the solving of which also requires information on productivity, labour and capital cost surprises. On the basis of equations (14), (15) and (17), it can be stated that

(20a) $s_t - \hat{s}_t = \theta_t$

(20b) $q_t - \hat{q}_t = s_t - \hat{s}_t + p_t - \hat{p}_t$

(20c) $r_t^n - \hat{r}_t^n = \theta_{t+1}$

(20d) $h_t - \hat{h}_t = s_t - \hat{s}_t + p_t - \hat{p}_t$

When the information in equations (20a-d) is utilized in the simultaneous model (18) - (19), the trend deviations in production and the price level can be expressed in terms of exogenous factors - i.e. the supply of money and productivity shocks. By combining the parameters appropriately, the equations of the trend deviations can thus be expressed in the following forms:

(21) $\quad y_t - \hat{y}_t = g_s(s_t - \hat{s}_t) + g_p(p_t - \hat{p}_t)$

(22) $\quad p_t - \hat{p}_t = \dfrac{1}{(1 + \alpha_1 + \alpha_2 g_p)} \left[(\bar{m}_t - \hat{\bar{m}}_t) - \alpha_2 g_s(s_t - \hat{s}_t) - \varepsilon_t \right]$

$\quad g_s = -\gamma(b_q - b_s) - (1 - \gamma)(b_h - b_s)$

$\quad g_p = -\gamma(b_q - b_p) - (1 - \gamma)(b_h - b_p)$

Equations (21) and (22) now constitute a recursive system of equations, in which the trend deviation of production can finally be solved solely as a function of exogenous factors. Generalizing the parameterization, the time path of real cyclical variations is determined as follows

$$(23) \quad y_t - \hat{y}_t = B_p\left[(\bar{m}_t - \hat{\bar{m}}_t) - \varepsilon_t\right] + B_s(s_t - \hat{s}_t)$$

$$B_p = \frac{g_p}{(1 + \alpha_1 + \alpha_2 g_p)}$$

$$B_s = g_s - \frac{g_p \alpha_2 g_s}{(1 + \alpha_1 + \alpha_2 g_p)}$$

According to equation (23), the functioning of the economy typically involves real cyclical variations. Surprises in the growth of productivity and the supply of money results in firms making incorrect production decisions and in investors making incorrect investment decisions. It is obvious that the central bank cannot stabilize cyclical variations by means of any systematic policy rule, because only surprises induce real changes in the economy. Only if the central bank is able to. link the supply of money with exogenous productivity shocks is it able to affect the real growth path of the economy. If, as an extreme example, the money supply rule is

$$(24) \quad \bar{m}_t = \hat{\bar{m}}_t - \frac{B_s}{B_p}(s_t - \hat{s}_t)$$

production will be fully stabilized on its expected value path.

The effects of increased efficiency in the payment system on the efficiency of monetary policy can be observed fairly easily in a model based on the Lucas mechanism. This is due to the fact that, owing to the assumption of flexible prices in the model, all effects are temporary effects of one period. From equations (22) and (23), it can be stated that the price and real effects of monetary policy connected with the model change as follows as the payment system becomes more efficient:

$$\frac{\partial^2 (p_t - \hat{p}_t)}{\partial(\bar{m}_t - \hat{\bar{m}}_t)\partial\alpha_1} = - \frac{1}{(1 + \alpha_1 + \alpha_2 g_p)^2} < 0$$

$$\frac{\partial^2 (y_t - \hat{y}_t)}{\partial(\bar{m}_t - \hat{\bar{m}}_t)\partial\alpha_1} = - \frac{g_p}{(1 + \alpha_1 + \alpha_2 g_p)^2} < 0$$

According to the cross-derivative expressions, the two effects weaken in line with the development of the payment system. Intuitively, the weakening in the inflationary impact can be attributed to the fact that the increase in the efficiency of the payment system increases the interest rate sensitivity of the demand for money and hence diminishes the partial demand for money. As a result, the economy is unable to absorb an increase in the supply of money of given size without a reduction in the sensitiveness of the economy to inflation. This directly lowers the rise in the nominal interest rate caused by the increase in the supply of money to the extent that the supply of and demand for money grow by the same amount. On the other hand, inflation and production surprises are positively correlated with each other owing to the Lucas mechanism.

4.2.2 Wage Rigidity and Policy Effects

Finally, we examine the economy in institutional conditions where nominal wages adjust slowly to variations in the value of the marginal product of labour. A wage determination process of this kind may arise as a consequence of a number of various basic phenomena in the labour market (e.g. individual or collective agreements and information problems). One technical construction which enables an analytical examination is Taylor's idea (1980a, b, 1986) of overlapping contracts. According to Taylor, a good approximation of the determination of wages in actual economies is obtained by assuming that a fraction x_n of labour negotiates in each period on a wage agreement binding for n periods ahead. When setting its wage level, each negotiating group takes into account the wage level to be reached, the results of other

negotiations and its own expectations about future economic
developments. The aggregate wage level is determined as a moving
average of the actual wages of different contracting groups.

The inclusion of wage or price rigidities in the model complicates the
dynamics of the model, in particular. Even very simple model structures
result in time paths for endogenous variables, for which it is difficult
or impossible to find explicit forms. So as to avoid difficulties
which are unreasonable from the point of view of the present purposes,
we eliminate the possibility of Lucas-type information mistakes from
the model framework, so that the impact of wage rigidity on the
functioning of the economy can be examined separately.

It is assumed that the economy functions in accordance with the
relationships specified in the following equations:

$$(25) \quad m_t^d - p_t = \alpha_1 r_t + \alpha_2 y_t + \varepsilon_t$$

$$(26) \quad y_t = -\gamma(q_t - p_t - s_t) - (1-\gamma)(h_t - p_t - s_t)$$

$$(27a) \quad w_t = \frac{1}{2}(w_{t-1} + \hat{w}_{t+1}) + \frac{1}{2}\delta(\hat{y}_t + \hat{y}_{t+1}) + \gamma_*$$

$$(27b) \quad h_t = \frac{1}{2}(w_t + w_{t-1})$$

$$(28) \quad m_t^d = \bar{m}_t$$

$$(29) \quad q_t = h_t$$

$$(30) \quad r_t = \hat{q}_{t+1} - q_t = \hat{h}_{t+1} - h_t$$

Unlike those presented above, all the variables in the model are
percentage deviations from the trend values of the variables concerned.

In the model (25) - (30), equations (25) and (28) are the money demand
and supply equations familiar from the previous models. Equation (27a)

specifies the dependence of the contract wage on past and future contracts and on excess supply in the contract period. The equation is based on the idea that in each period half the labour force negotiates a contract wage for two years at a time, that the expected excess demand situations during the agreement period (= $\hat{y}_t + \hat{y}_{t+1}$ ~ expected deviations of supply from its long-term trend path) raise the contract wage by coefficient δ and that the contract wage includes a random element (γ_t ~ (0, σ_h^2) i.i.d.). Equation (27b) states that the actual wage h_t is the average of the contract wages of the previous and current periods. Equation (29) includes the assumption that firms do not adjust their input structures in the short term: thus the price of capital must follow the contract wage in the model. The assumption included in equation (29) greatly simplifies the dynamics of the model: as a result, the interest rate is determined directly according to equation (30). The assumption that the input structure of production is fixed in the short term means that the time path of total production is determined solely by the time paths of contract wages, the price level and productivity. Utilizing equation (29), the production equation (26) can be written in the following form:

(31) $\quad y_t = - (h_t - p_t - s_t)$

The model (25) - (31) specifies the time paths of contract wages, the price level and production in terms of exogenous variables (productivity, money supply and contract wage shocks). For the sake of comparison, it can be stated that Taylor's basic model (e.g. Taylor (1980a)) is a special case of model (25) - (31), in which the coefficient $\alpha_1 = 0$. In that case, the demand for money is not affected by the interest rate at all and consequently the interest rate does not play any role in the economy described by the model.

If the production equation (31) is inserted in the equation for the demand for money (25) and the contract wage equation (27a), the time paths of the expected price level and the expected contract wage can be solved simultaneously from these. Rearranging the terms, we obtain the following time paths:

(32a) $\quad \hat{w}_t = G(L)^{-1} \dfrac{\delta}{2(1+\alpha_2)} \left[\hat{s}_t + \hat{s}_{t+1} + \hat{m}_t + \hat{m}_{t+1} \right]$

(32b) $\quad \hat{h}_t = \dfrac{1}{2} (\hat{w}_t + \hat{w}_{t-1})$

(33) $\quad \hat{p}_t = \dfrac{1}{(1+\alpha_2)} \left[\hat{m}_t + \alpha_1 (\hat{h}_{t+1} - \hat{h}_t) + \alpha_2 (\hat{h}_t - \hat{s}_t) \right]$

where $\quad G(L) = \left[1 + \dfrac{1}{2}\delta + \dfrac{1}{4}\dfrac{\delta\alpha_1}{(1+\alpha_2)} - \dfrac{1}{2}\dfrac{\delta\alpha_2}{(1+\alpha_2)} \right]$

$$- \left[\dfrac{1}{2} - \dfrac{1}{4}\delta - \dfrac{1}{4}\dfrac{\delta\alpha_1}{(1+\alpha_2)} + \dfrac{1}{4}\dfrac{\delta\alpha_2}{(1+\alpha_2)} \right] L$$

$$- \left[\dfrac{1}{2} - \dfrac{1}{4}\delta + \dfrac{1}{4}\dfrac{\delta\alpha_1}{(1+\alpha_2)} + \dfrac{1}{4}\dfrac{\delta\alpha_2}{(1+\alpha_2)} \right] L^{-1}$$

$$- \dfrac{1}{4}\dfrac{\delta\alpha_1}{(1+\alpha_2)} L^{-2}$$

$$L[Z_t] = Z_{t-1}$$

$$L^{-1}[Z_t] = Z_{t+1}$$

The time path of expected production is obtained by subtracting the expected value from equation (31) and substituting the information in equations (32) and (33) for price and wage expectations.

Even in the simple case examined above, the lag operator polynomial G(L) is very complicated, and it is not possible to factorize polynomial G(L) so that equations (32) and (33) might be solved explicitly. However, the properties of the model provide sufficient information without solving its closed form. If it is assumed that the exogenous variables stabilize at constant levels $(\bar{m}_t = \mu, s_t = \sigma, \gamma_t = 0; \; \forall \, t)$ for a sufficiently long period, it can

be observed that there is a steady-state solution to the model. It is easy to see that if the polynomial G(L) operates at constant levels, $G(L)^{-1} = \delta/1+\alpha_2$. As a result, the steady-state solutions for the contract wage, the price level and production are as follows:

(34) $\quad w_{ss} = h_{ss} = \sigma + \mu$

(35) $\quad p_{ss} = \mu$

(36) $\quad y_{ss} = 0$

If the random processes of the exogenous variables have no trend, the endogenous variables of the model always converge to the above steady-state solutions in the long term. By contrast, in the short term the variables may deviate significantly from the above values. Suppose, for example, that the supply of money and productivity follow the following processes

(37) $\quad \bar{m}_t = \mu + \eta_t; \qquad \eta_t \sim g_m(0, \sigma_m^2) \text{ i.i.d.}$

(38) $\quad s_t = \sigma + \theta_t; \qquad \theta_t \sim g_s(0, \sigma_s^2) \text{ i.i.d.}$

Then contract wages, the price level and production behave in the following way:

(39) $\quad w_t = \hat{w}_t + \gamma_t = G(L)^{-1} \frac{\delta}{2(1+\alpha_2)} [\hat{s}_t + \hat{s}_{t+1} + \hat{m}_t + \hat{m}_{t+1}] + \gamma_t$

(40) $\quad p_t = (\frac{1}{1+\alpha_2}) [m_t + \alpha_1(\hat{h}_{t+1} - h_t) + \alpha_2(h_t - s_t) - \varepsilon_t]$

(41) $\quad y_t = - (h_t - p_t - s_t)$

Thus, disturbances in wage determination, productivity and the demand for and supply of money lead to slowly recurring deviations from the trend paths.

Hence it is characteristic of the model that, while money is neutral in the long term, it is non-neutral in the short term. Equation (36) indicates that steady-state production is independent of the supply of money. By contrast, equation (41) contains the money supply shocks, in which case variations in production can be affected by short-term monetary policy.

Conclusions about the effects of increased efficiency in the payment system in the model cannot be drawn directly from the solutions of the endogenous variables, unless it is possible to factorize the coefficient polynomial $G(L)$. However, it is easy to obtain information on the effects of increased efficiency by means of simulation. In the following simulation experiments it is assumed that $\delta = 1$ and $\alpha_2 = 2/3$, while δ_1 is assigned different values ($\alpha_1 = 0, 1, 2$). On these assumptions, the implicit solution of the contract wage can be written as the function of α_1 in the following form:

$$(42) \quad (1.3 + 0.15\alpha_1)\hat{w}_t - (0.3 - 0.15\alpha_1)\hat{w}_{t-1} - (0.3 + 0.15\alpha_1)\hat{w}_{t+1}$$

$$- 0.15\alpha_1\hat{w}_{t+2} = 0.3(\hat{s}_t + \hat{s}_{t+1} + \hat{m}_t + \hat{m}_{t+1})$$

We then simulate the effects of temporary and permanent expected money supply and productivity shocks on the contract wage, the price level and production. Economic agents become aware of these shocks at time 0 and they are determined in the following way:

a) permanent shocks

$\quad s_0, \ldots, s_{T-1} = 0; \ s_T = 3; \ s_{T+1}, \ldots = 3$

$\quad m_0, \ldots, m_{T-1} = 0; \ m_T = 3; \ m_{T+1}, \ldots = 3$

b) temporary shocks

$\quad s_0, \ldots, s_{T-1} = 0; \ s_T = 3; \ s_{T+1}, \ldots = 0$

$\quad m_0, \ldots, m_{T-1} = 0; \ m_T = 3; \ m_{T+1}, \ldots = 0$

The results of the simulation experiments are shown in the following charts.[6] The value T = 20 (period T ends at time 20) is used in the tests. Generally speaking it can be stated that a more efficient payment system means that the effects on all the variables of the model are reduced. The effects on the price and wage levels are felt earlier as the payment system becomes more efficient. Permanent shocks result in a permanent rise in the price and wage levels in the model. Production remains on its trend path in the long term and in the case of both temporary and permanent shocks. Temporary shocks temporarily raise the wage level. The price level and production also rise temporarily. The impact of the interest rate on the demand for money ($\alpha_1 \neq 0$) leads to overshooting in the price level as a result of both temporary and permanent shocks. In the time path for production, overshooting also emerges in Taylor's special case ($\alpha_1 = 0$). The motive force in the model is the profitability effect, which arises from non-simultaneous changes in prices and wages (and capital costs) and makes firms change their production. Contract wages are affected by both expected and realized shocks in the supply of money and productivity with weights determined by the polynomial $G(L)^{-1}$. On the other hand, expected changes in the wage level (and the difference between the nominal wage and productivity, and the supply of money) affect the price level immediately for one period. Hence the price level and wages adjust so that, in the case of temporary shocks, the gross income of the representative firm is lower than costs ($p_t + s_t < h_t$) both before and after the periods in which the shocks occur, but higher during the period in which the shocks occur. Similarly, in the case of permanent shocks, revenue is lower than costs ($p_t + s_t < h_t$) before the period in which the shocks occur and higher ($p_t + s_t > h_t$) thereafter.

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[6]The simulations were carried out by Ms. Anne Kolehmainen of the Model Group of the Bank of Finland's Research Department.

CHART 1a. LOGARITHMIC TREND DEVIATION OF THE WAGE LEVEL,
          TEMPORARY SHOCK

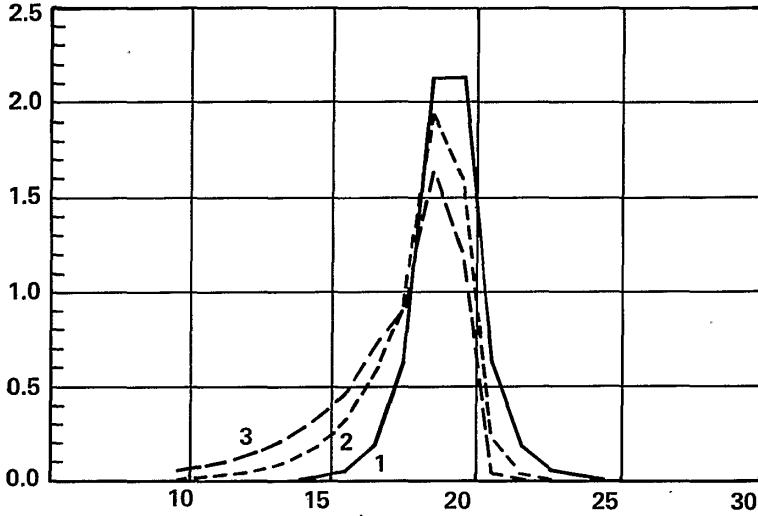1 $\alpha_1 = 0$
2 $\alpha_1 = 1$
3 $\alpha_1 = 2$

CHART 1b. LOGARITHMIC TREND DEVIATION OF THE WAGE LEVEL,
          PERMANENT SHOCK

1 $\alpha_1 = 0$
2 $\alpha_1 = 1$
3 $\alpha_1 = 2$
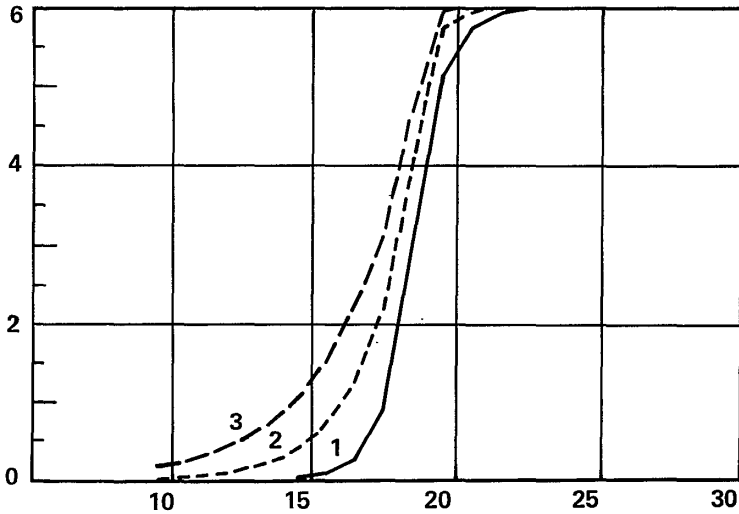
CHART 2a. LOGARITHMIC TREND DEVIATION OF THE PRICE LEVEL,
         TEMPORARY SHOCK
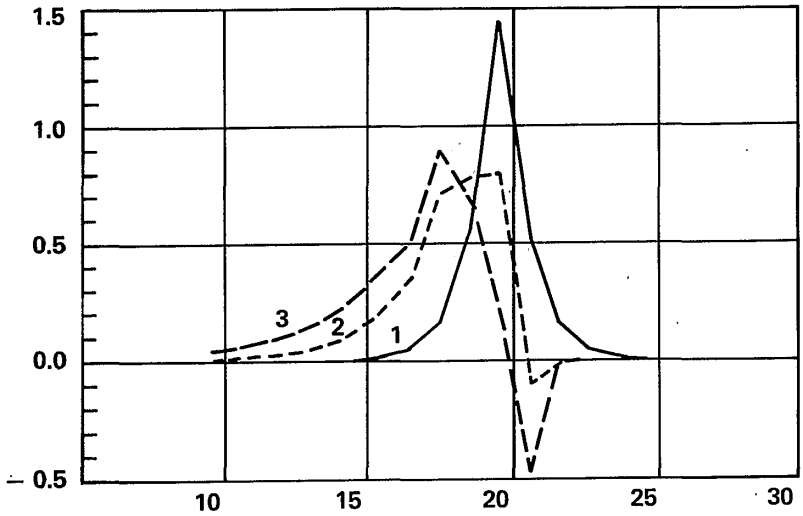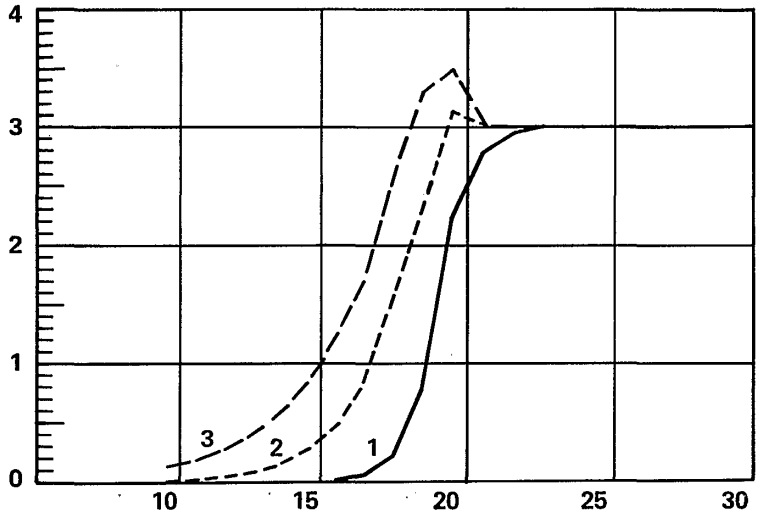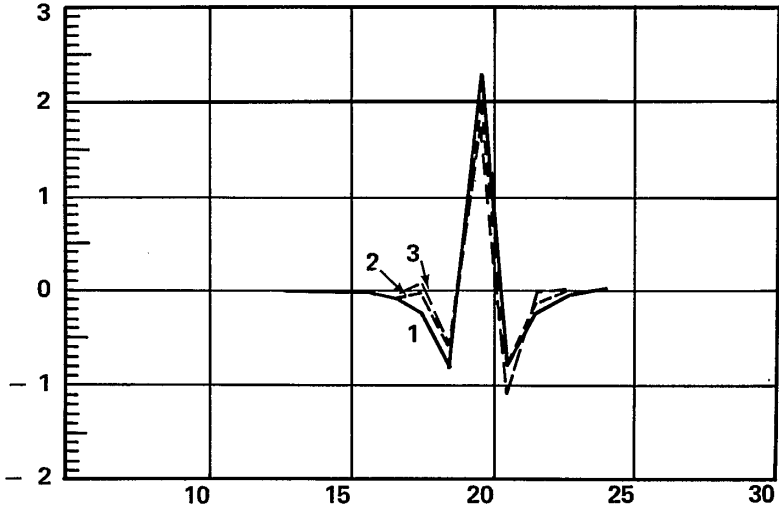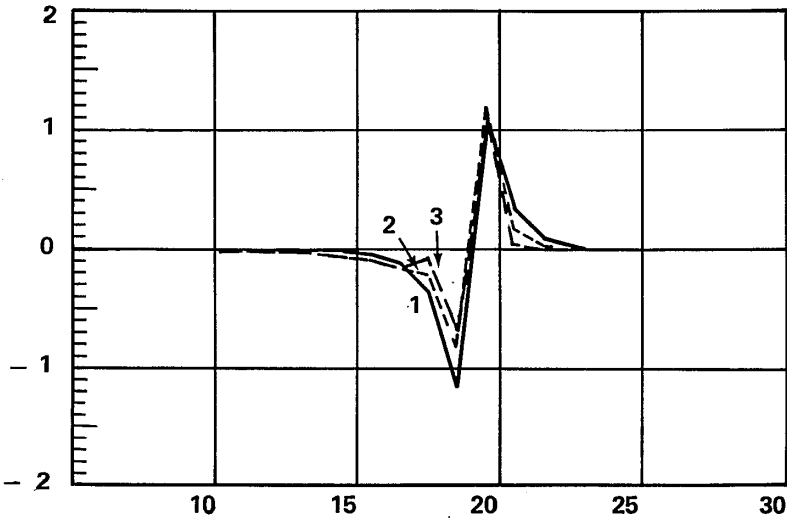
1 $\alpha_1 = 0$
2 $\alpha_1 = 1$
3 $\alpha_1 = 2$

CHART 2b. LOGARITHMIC TREND DEVIATION OF THE PRICE LEVEL,
         PERMANENT SHOCK

1 $\alpha_1 = 0$
2 $\alpha_1 = 1$
3 $\alpha_1 = 2$

CHART 3a.   LOGARITHMIC TREND DEVIATION OF PRODUCTION,
            TEMPORARY SHOCK

1   $\alpha_1 = 0$
2   $\alpha_1 = 1$
3   $\alpha_1 = 2$

CHART 3b.   LOGARITHMIC TREND DEVIATION OF PRODUCTION,
            PERMANENT SHOCK

1   $\alpha_1 = 0$
2   $\alpha_1 = 1$
3   $\alpha_1 = 2$

4.3 Payment Systems and Cyclical Variations in the Economy

The implications of different payment systems for cyclical variations
in the economy have received very little attention and they are a
difficult area to study in economics. The present study is no exception
in this respect. It is not possible to thoroughly investigate the
problem here; rather, we have to be content with simply introducing
the issues as they arise, using the model frameworks developed above.

Broadly speaking, a comparison of payment systems from the
macroeconomic point of view would require both a study of differences
in efficiency between systems (e.g. the functioning of private versus
public systems or the real resources used by different systems) and an
examination of the properties of the supply processes of liquidity
implied by different systems. However, in this context, we examine the
issue from a very restricted angle. As is the tradition in monetary
theory we assume that the two payment systems being compared both
produce liquidity free of cost, i.e. changes in the supply of money do
not give rise to costs in either of the systems. In that case, the
payment systems differ from each other only with respect to the money
supply rule. In the first payment system, the supply of money is
assumed to follow a fully exogenous stochastic process. Intuitively,
this system could correspond to, for example, a situation of
privatized competitive supply of money or to a case of a fully passive
central bank. In the case of the first payment system, the money
supply rule is as follows

$$(43) \quad \bar{m}_t^1 = \mu_1 + n_t \quad ; \quad En_t = 0, \ \text{Var} \ n_t = \sigma_m^2$$

In the second payment system, it is assumed that the supply of money
is fully controlled by the central bank and that the central bank
endeavours to pursue counter-cyclical policies. Accordingly, the
central bank's money supply is of the following form

(44) $\quad \bar{m}_t^2 = \beta_s(L)Z_t$

$\beta_s(L)$ is the lag polynomial and Z_t the vector of exogenous variables.

In its policy rule (44), the central bank sets the coefficients of the lag polynomial so as to achieve a certain objective as well as possible.

In the following, we compare the properties of different models in the cases of different payment systems only with respect to the variances of output and the price level. Thus the underlying assumption here is that, in the case of the active pursuit of counter-cyclical policies, the central bank aims at minimizing the variance of either production or the price level. It is assumed that the only sources of disturbances in the economy are productivity shocks θ_t and contract wage shocks γ_t in the wage rigidity model.

In the cases of the first model (the pure money market model) and the second model (the model with flexible prices and wages), the real economy is independent of money market phenomena, so that it is sensible to assume that production is constant. In that case, the same solutions with regard to the price and interest rate levels and the demand for money (equations (4), (5), (7) and (8)) are valid in both models. In the cases of the different payment systems, the variances of the price level (logarithm) are as follows

(45) $\quad \mathrm{var}(p_t)^1 = \sigma_m^2 + \alpha_1^2 \sigma_s^2 - 2\alpha_1 \rho_{ms} \sigma_m \sigma_s$

(46) $\quad \mathrm{var}(p_t)^2 = \beta_s^2 \sigma_s^2 + \alpha_1^2 \sigma_s^2 - 2\beta_s \alpha_1 \sigma_s^2$

If a central bank pursuing stabilization policies wishes to minimize the variance of the price level in equation (46), it sets the parameter $\beta_s = \alpha_1$. The variance of the price level then disappears completely. By contrast, in an economy with an exogenous money supply process, the variance of the price level is always positive, unless

$\rho_{ms} = 1$ and $\sigma_m = \sigma_s$. Accordingly, a central bank pursuing stabilization policies is better able to stabilize the price level through optimal policies than through passive policies. However, this does not entail any other advantages than its possible intrinsic value.

Next we examine a model based on the Lucas supply function and mistakes in which the time path of production also depends on both exogenous shocks and the supply of money. In the cases of alternative assumptions about the supply of money, the variances of production and the price level implied by the model are as follows

$$(47) \quad var(y_t)^1 = B_p^2\sigma_m^2 + B_s^2\sigma_s^2 + 2B_pB_s\rho_{ms}\sigma_m\sigma_s$$

$$(48) \quad var(p_t)^1 = k_p^2[\sigma_m^2 + k_s^2\sigma_s^2 - 2k_s\rho_{ms}\sigma_m\sigma_s]$$

$$(49) \quad var(y_t)^2 = [\beta_s^2B_p^2 + B_s^2 + 2\beta_sB_pB_s]\sigma_s^2$$

$$(50) \quad var(p_t)^2 = k_p^2[\beta_s^2 + k_s^2 - 2k_s\beta_s]\sigma_s^2$$

where

$$k_p = [1 + \alpha_2g_p + \alpha_1]$$

$$k_s = \alpha_2g_s - \alpha_1$$

It can again be noted that the variances of production and the price level associated with the exogenous supply of money are finite and positive. On the other hand, a new problem arises in connection with the activities of a central bank pursuing stabilization policies. If the central bank sets the money supply so that $\beta_s = k_s$, the variance of the price level is completely eliminated. This does not, however, eliminate the variance of production, which remains at the level var $(y_t^2) \mid_{\beta_s = k_s} = [k_s^2B_p^2 + B_s^2 + 2k_sB_pB_s]\sigma_s^2$. If, by contrast, the central bank sets the money supply rule so that $\beta_s = -B_s/B_p$, the variance of production is totally eliminated. However, the variance

of the price level price level then becomes positive, setting at
the level $\text{var}(p_t^2) \mid_{\beta_s = -B_s/B_p} = [(B_s/B_p)^2 + k_s^2 + 2k_s(B_s/B_p)]\sigma_s^2$.
Accordingly, there is as trade-off situation resembling the Phillips
curve between the variances of production and the price level in which
the central bank is able to reduce real fluctuations in the economy
resulting from shocks by accepting more variation in the price level
and the rate of inflation.

The trade-off between nominal and real fluctuations can be
formalized by defining the constant $a \in [0,1]$ and by setting the
policy rule so that $\beta_s = k_s - ag_s/k_p g_p$. From the specification
of the policy rule it can be observed that, with the value $a = 0$, the
rule minimizes nominal fluctuations and, with the value $a = 1$, it
minimizes real variations. The general expressions for the variances
of the price level and output with arbitrary values of a are as follows

$$(51) \quad \text{var}(y_t)^2 \Big|_{\beta_s = k_s + \frac{ag_s}{k_p g_p}} = (1-a)^2 g_s^2 \sigma_s^2$$

$$(52) \quad \text{var}(p_t)^2 \Big|_{\beta_s = k_s + \frac{ag_s}{k_p g_p}} = a^2 g_s^2 \sigma_s^2$$

From the expressions for variances it can be seen that increasing the
constant a between (0,1) reduces monotonously the variance of output
and increases monotonously the variance of the price level.

Since stabilization policies involve a trade-off between the price
objective and the real objective, in principle it is possible that an
economy with an exogenous money supply can achieve better real economic
stability than an economy in which the central bank pursues active
counter-cyclical policies. If the central bank endeavours through its
policies to reduce variations in the price level to a minimum, such a
situation may indeed arise.

Finally, we examine the wage rigidity model in cases of different
institutional conditions and of different exogeneous variables. The

variances of production and the price level implied by the model are as follows

$$(53) \quad \text{var}(y_t)^1 = \sigma_h^2 + \sigma_s^2 + \sigma_p^2 - 2\rho_{hp}\sigma_h\sigma_p - 2\rho_{hs}\sigma_h\sigma_s + 2\rho_{ps}\sigma_p\sigma_s$$

$$(54) \quad \text{var}(p_t)^1 = \frac{1}{(1+\alpha_2)^2} [\sigma_m^2 + \alpha_2^2\sigma_s^2 + (\alpha_2-\alpha_1)^2\sigma_h^2 - 2\alpha_2\rho_{ms}\sigma_m\sigma_s$$

$$+ 2(\alpha_2-\alpha_1)\rho_{mh}\sigma_m\sigma_h - 2\alpha_2(\alpha_2-\alpha_1)\rho_{sh}\sigma_s\sigma_h]$$

$$(55) \quad \text{var}(y_t)^2 = \sigma_h^2 + \sigma_s^2 + \sigma_p^2 - 2\beta_h\rho_{hp}\sigma_h\sigma_p - 2\rho_{hs}\sigma_h\sigma_s + 2\beta_p\rho_{ps}\sigma_p\sigma_s$$

$$(56) \quad \text{var}(p_t)^2 = \frac{1}{(1+\alpha_2)^2} [\beta_s^2\sigma_s^2 - 2\beta_s\alpha_2\sigma_s^2 + 2\beta_s(\alpha_2-\alpha_1)\rho_{sh}\sigma_s\sigma_h$$

$$+ \beta_h^2\sigma_h^2 2\beta_h\alpha_2\rho_{sh}\sigma_s\sigma_h + 2\beta_h(\alpha_2-\alpha_1)\sigma_h^2 + \alpha_2^2\sigma_s^2 + (\alpha_2-\alpha_1)^2\sigma_h^2$$

$$- 2\alpha_2(\alpha_2-\alpha_1)\rho_{sh}\sigma_s\sigma_h]$$

According to expressions (53) and (54), in an economy with an exogenous money supply the variances of both production and the price level are again positive and finite. In the case of an active central bank, the results are also similar to those in the model of information differences. However, in the wage rigidity model, the situation is more complicated as there are now two sources of exogenous disturbances. The policy trade-off can, in principle, also be determined on the basis of equations (55) and (56), although the expressions become unacceptably complicated. It is therefore assumed that $\rho_{sh} = 0$, in which case the exogeneous processes are uncorrelated with each other. The superscript y is used to denote the values of policy parameters minimizing the variation of production and the superscript p to denote those minimizing the variation of the price level. On these assumptions, these variances are minimized (obtain the value zero) with the following values of the parameters:

(57a) $\quad \beta_s^y = -(1-\alpha_2) < 0$

(57b) $\quad \beta_h^y = -(\alpha_2-1-\alpha_1) > 0$

(57c) $\quad \beta_s^p = \alpha_2 > 0$

(57d) $\quad \beta_h^p = -(\alpha_2-\alpha_1) < 0$

Let us further define the constants $a^s \in [-(1-\alpha_2), \alpha_2]$ and $a^h \in [-(\alpha_2-\alpha_1), -(\alpha_2-1-\alpha_1)]$ and the general policy rules $\beta_s = a^s$ and $\beta_h = a$. Hence, the expressions for the variances of production and the price level can be written in the forms

(58) $\quad var(y_t)^2 = [a^s + (1-\alpha_2)]^2\sigma_s^2 + [a^h - (1+\alpha_1-\alpha_2)]^2\sigma_h^2$

(59) $\quad var(p_t)^2 = [a^s-\alpha_2]^2\sigma_s^2 + [a^h+(\alpha_2-\alpha_1)]^2\sigma_h^2$

The general variance of production is an increasing function of the parameter a^s and a decreasing function of the parameter a^h, whereas the variance of the price level is a decreasing function of the parameter a^s and an increasing function of the parameter a^h. Thus, the parameters a^s and a^h determine the trade-off between real and price variations in economic policy.

4.3.1 Summary of the Macroeconomic Properties of Payment Systems

The sketchy comparisons of the macroeconomic properties of different payment systems presented above were based on a highly restrictive assumption. The underlying assumption was that the money supply rules built into the macromodel fully reflect differences in payment systems in a macroeconomic sense. In this context, the latter refers merely to the differences between typical macromodels in cyclical dynamics when the mechanisms for the determination of the quantity of money associated

with different systems have been incorporated in them. If this
assumption is accepted as a point of departure, two major conclusions
can be drawn on the basis of the foregoing analysis. First, it can be
stated that if, because of information differences or wage/price
rigidities, real cyclical variations can appear in an economy, then
the policy authorities face a trade-off situation between different
policy objectives. In particular the policy institution has to decide
how much or little price variation it is ready to accept in the economy.
This implies inversely the amount of real cyclical variation appearing
in the economy. Secondly, if the policy authorities wish or are
compelled, for one reason or another, to stabilize the price level at
least to some extent it is possible that, from the welfare point of view,
meaning here the stability of aggregate consumption possibilities, a
competitive economy performs better than an economy regulated by the
central bank. In that case, less real cyclical variations would appear
in a competitive economy than in one regulated by active policy
authorities. In this limited sense, it is possible that, for example,
an economy with a fully privatized payment system would be able to
operate more efficiently from the macroeconomic point of view than an
economy controlled by a central bank pursuing counter-cyclical policies.

REFERENCES

ARTIS, M. - LEWIS, M. (1984) "The Demand for Money - Stable or Unstable", The Banker, 124.

AUTIO, JOHANNA (1987) Charge and Credit Cards in Finland (in Finnish). The Research Centre for Household and Consumer Matters 2/1987.

AUTIO, JOHANNA - JUTILA, TARJA (1986) Plastic Means of Payment (in Finnish). Preliminary Study. The Research Centre for Household and Consumer Matters 2/1986.

BARRO, ROBERT (1978) Unanticipated Money Growth, Output and the Price Level in the United States. AER.

BARRO, ROBERT (1979) Money and the Price Level under the Gold Standard. EJ.

BARRO, ROBERT - RUSH, MARK (1980) Unanticipated Money and Economic Activity. In Stanley Fischer (ed.) (1980): Rational Expectations and Economic Policy. University of Chicago Press.

BASU, PARANTAP (1987) An Adjustment Cost Model of Asset Pricing. IER vol. 28.

BAUMOL, WILLIAM J. (1952) The Transaction Demand for Cash: An Inventory Theoretic Approach. QJE.

BAUMOL, WILLIAM J. - PANZAR, JOHN C. - WILLIG, ROBERT D. (1982) Contestable Markets and the Theory of Industry Structure. Harcourt Brace Jovanovich Inc.

BIS (1985) Bank for International Settlements; "Payment Systems in Eleven Developed Countries", Basle.

BLACK, FISCHER (1970) The Effects of Uncontrolled Banking. JBR.

BLANCHARD, OLIVIER (1983) Price Asynchronization and Price Level Inertia. In Dornbush Rudiger - Simonsen, Mario (eds.): Inflation, Debt and Indexation. MIT Press.

BLANCHARD, OLIVIER JEAN (1987) Why Does Money Affect Output? A Survey. Forthcomining in Handbook of Monetary Economics.

BORDO, MICHAEL D. (1986a) Explorations in Monetary History: A Survey of the Literature. NBER WP 1821.

BORDO, MICHAEL D. (1986b) Money, Deflation and Seigniorage in the Fifteenth Century. A review of essay. JME 18 (1986).

BRANSON, WILLIAM H. (1979) Asset Markets and Relative Prices in Exchange Rate Determination. In A. Lindbeck (ed.): Inflation and Employment in Open Economies, North-Holland.

BREEDEN, DOUGLAS T. (1979) An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities. JFE.

BRUNNER, KARL - MELTZER, ALLAN H. (1971) The Uses of Money: Money in the Theory of an Exchange Economy. AER vol. 61.

BUITER, WILLEM H. (1986) A "Gold Standard" isn't Viable Unless Supported by Sufficiently Flexible Monetary and Fiscal Policy. NBER WP 1903.

CASS, DAVID - YAARI, MENAHEM (1966) A Re-Examination of the Pure Consumption Loans Model. JPE.

CAGAN, P. (1956) The Monetary Dynamics of Hyperinflation. In M. Friedman (ed.): Studies in the Quantity Theory of Money. University of Chicago Press.

CLAASSEN, EMIL-MARIA (1985) The lender-of-last-resort Function in the Context of National and International Financial Crises. The Hoover Institution WP E-85-32.

CLOWER, ROBERT W. (1967) A Reconsideration of the Microfoundations of Monetary Theory. WEJ, vol. 6.

CLOWER, ROBERT W. (1969a) (ed.) Monetary Theory. Penguin Books.

CLOWER, ROBERT W. (1969b) Introduction. In R.W. Clower (ed.): Monetary Theory. Penguin Books (1969).

CUDDINGTON, JOHN T. (1982) Currency Substitution, Capital Mobility and Money Demand. ITE WP 216.

COX, JOHN C. - INGERSOLL, JONATHAN E. - ROSS, STEPHEN A. (1985) An Intertemporal General Equilibrium Model of Asset Prices. Econometrica vol. 53.

CUTHBERTSON, KEITH - TAYLOR MARK P. (1987) The Demand for Money: A Dynamic Rational Expectations Model. EJ, 97.

DANIEL, BETTY C. (1986) The Transactions Demand for Money in a Two-Currency Economy. A note. JME 18.

DIAMOND, DOUGLAS W. - DYBVIG PHILIP H. (1983) Bank Runs, Deposit Insurance, and Liquidity. JPE vol. 91.

DIAMOND, PETER (1965) National Debt in a Neoclassical Growth Model. AER.

DIXIT, AVINASH (1986) Comparative Statics for Oligopoly. IER vol. 27.

DORNBUSCH, RUDIGER - SIMONSEN, MARIO H. (1987) Inflation Stabilization with Incomes Policy Support: A Review of the Experience in Argentina, Brazil and Israel. NBER WP 2153.

DWYER, GERALD P., Jr. - SAVING, THOMAS R. (1986) Government Revenue from Money Creation with Government and Private Money. JME 17.

EICHENBAUM, MARTIN - MARTIN, KENNETH J. (1986)   Do Equilibrium Real Business Cycle Theories Explain Postwar U.S. Business Cycles? In Stanley Fischer (ed.): NBER Macroeconomics Annual 1986. MIT Press.

FAMA, EUGENE F. (1980) Banking in the Theory of Finance. JME.

FAMA, EUGENE F. (1983) Financial Intermediation and Price Level Control. JME 12.

FASE, M. - van NIEUWKERK (1977) "The Demand for Bank Notes in Four Countries", De Nederlandsche Bank N.V., Quarterly Statistics, No. 1.

FEENSTRA, ROBERT C. (1986) Functional Equivalence between Liquidity Costs and the Utility of Money. JME 17.

FISCHER, STANLEY (1977) Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule. JPE.

FISCHER, STANLEY (1982) Seignorage and the Case for a National Money. JPE vol. 90.

FISCHER, STANLEY (1986a) Friedman versus Hayek on Private Money. A Review Essay . JME 17.

FISCHER, STANLEY (1986b) Monetary Rules and Commodity Money Schemes under Uncertainty. JME 17.

FLOOD, ROBERT P. - GARBER, PETER M. (1980) Market Fundamentals Versus Price-Level Bubbles: The First Tests. JPE, vol. 88.

FRIEDMAN, MILTON (1951) Commodity - Reserve Currency. JPE vol. LIX.

FRIEDMAN, MILTON (1959) A Program for Monetary Stability. Fordham University Press.

FRIEDMAN, MILTON (1986) Quantity Theory of Money. Hoover Institution WP. E-86-7.

FRIEDMAN, MILTON - SCHWARTZ, ANNA J. (1986) Has Government Any Role in Money? JME 17.

GIOVANNINI, ALBERTO (1986) "Rules of the Game" During the International Gold Standard: England and Germany. JIMF.

GOLDFELD, S.M. (1973) "The Demand for Money Revisited", Brookings Papers on Economic Activity, 3.

GOLDFELD, S.M. (1976) "The Case of Missing Money", Brookings Papers on Economic Activity, 6.

GOODHART, C.A.E. (1987) Why do Banks Need a Central Bank? OEP 39.

GORDON, ROBERT J. (1984) The Short-Run Demand for Money: A Reconsideration. JMCB vol. 16.

HALL, ROBERT (1982) Explorations in the Gold Standard and Related Policies for Stabilizing the Dollar. In R.E. Hall (ed.): Inflation: Causes and Effects. The University of Chigaco Press.

HALL, ROBERT E. (1983) Optimal Fiduciary Monetary Systems. JME 12.

HALL, ROBERT E. (1984) Optimal Monetary Institutions and Policy. Hoover Institution WP E-84-11.

HAYEK, FRIEDRICH von (1976) Denationalization of Money. Institute of Economic Affairs.

HENDRY, D. - MIZON, G. (1978) "Serial Correlation as a Convenient Simplification, not a Nuisance: A Comment on a Study of the Demand for Money by the Bank of England", Economic Journal, 88.

HONKAPOHJA, SEPPO - LEMPINEN, URHO (1987) On Government Deficits and Speculation. Bank of Finland Research Papers, TU 9/87.

JEVONS, W.S. (1910) Barter, in Clower (ed.) (1969).

JOHNSON, HARRY G. (1968) Problems of Efficiency in Monetary Management, JPE vol. 76.

JUDD, J. - SCADDING, J (1982) "The Search for a Stable Money Demand Function: A Survey of the Post-1973 Literature", Journal of Economic Literature.

KETTUNEN, A. (1986) "Payment Terminal - Does it Pay to the Trade Sector" (in Finnish), a lecture in a Payment Terminal Conference, January 27 - 29, 1986.

KIM, MOSHE (1985) Scale Economies in Banking: A Methodological Note. JMCB, vol. 17.

KING, ROBERT G. (1983) On the Economics of Private Money. JME 12.

KING, ROBERT G. - PLOSSER, CHARLES I. (1986) Money as the Mechanism of Exchange. JME 17.

KLEIN, BENJAMIN (1974) The Competitive Supply of Money. JMCB, vol. 6.

KOSKELA, E. - VIRÉN, M. (1986a) "Endogenous Policy, Structural Shift, and Demand for Money", Bank of Finland, Research Department, Research Papers, TU 4/86.

KOSKELA, E. - VIRÉN, M. (1986b) "Modelling the Behaviour of Money Stock under Various Monetary Targeting Procedures", Bank of Finland, Research Department, Research Papers, TU 15/86.

LANCASTER, K. (1971) Consumer Demand: A New Approach. Columbia University Press.

LEMPINEN, U. (1980) "On the Forecasting of the Demand and Manufacturing Needs of Notes and Coin " (in Finnish), Bank of Finland, Monetary Policy Department, Discussion Papers, RP 1/82.

LILJA, R. - LEMPINEN, U. (1987) The Finnish Payment System: An International Comparison, Bank of Finland Monthly Bulletin, April 1987.

LIPPMAN, STEVEN A. - McCALL, JOHN J. (1986) An Operational Measure of Liquidity. AER.

LUCAS, ROBERT E. (1972) Expectations and the Neutrality of Money. JET.

LUCAS, ROBERT E. (1973) Some International Evidence on Output - Inflation Tradeoffs. AER.

LUCAS, ROBERT E. (1986) Principles of Fiscal and Monetary Policy. JME 17.

LUCAS, ROBERT E. (1987) Models of Business Cycles. Basil Blackwell.

LUCAS, ROBERT E. - STOKEY, NANCY L. (1987) Money and Interest in a Cash-in-Advance Economy. Econometrica, vol. 55.

TERMINAL PROJECT (1982) Final Report: "On the Need, Prerequisites, Costs and Implementation of a Uniform Terminal System in Finland" (in Finnish), the project team: K. Jäämeri, H. Blumenthal, A Lehtelä, I. Paalosmaa and V. Pitkänen.

MAYER, HELMUT W. (1986) Private ECUs: Potential Macroeconomic Policy Dimensions. BIS economic papers 16.

McCALLUM, BENNETT T. (1985) Bank Deregulation, Accounting Systems of Exchange, and the Unit of Account: A Critical Review. CRCS 23 (1985). North Holland.

McCALLUM, BENNETT T. (1986) On "Real" and "Sticky-Price" Theories of the Business Cycle. JMCB, vol. 18.

McCALLUM, BENNETT T. - GOODFRIEND, MARVIN S. (1987) Money: Theoretical Analysis of the Demand for Money. NBER WP 2157.

McKIBBIN, WARWICK J. - SACHS, JEFFREY D. (1986) Comparing the Global Performance of Alternative Exchange Arrangements. Unpublished draft.

MERTON, ROBERT C. (1971) Optimum Consumption and Portfolio Rules in a Continuous Time Model. JET.

MERTON, ROBERT C. (1973) An Intertemporal Capital Asset Pricing Model. Econometrica.

MESTER, LORETTA J. (1987) A Multiproduct Cost Study of Savings and Loans. JFin. vol. XLII.

MILLER, MERTON H. - ORR, DANIEL A Model of the Demand for Money by Firms. QJE.

MIRON, JEFFREY A. (1986) Financial Panics, the Seasonality of the Nominal Interest Rate, and the Founding of the FED AER.

MURRAY, J. - WHITE, R. (1980) "Economies of Scale in Deposit-Taking Financial Institutions in Canada", Journal of Money, Credit and Banking, vol.12.

MURRAY, J. - WHITE, R. (1983) "Economies of Scale and Economies of Scope in Multiproduct Financial Institutions: A Study of British Columbia Credit Unions", Journal of Finance, vol. XXXVIII.

NIEHANS, JÜRG (1975) The Theory of Money. The John Hopkins University Press.

NORMAN, ALFRED LORN (1987) A Theory of Monetary Exchange. RESTUD LIV.

OBSTFELD, MAURICE - ROGOFF, KENNETH (1983) Speculative Hyperinflations in Maximizing Models: Can We Rule Them Out? JPE vol. 91.

OSTROY, J. - STARR, R.M. (1974) Money and the Decentralization of Exchange. Econometrica.

PATINKIN, DON (1965) Money, Interest and Prices. Harper & Row.

PIGOU, A.C. (1941) Money a Veil, in Clower (ed.) (1969).

POSTLEWAITE, ANDREW - VIVES, XAVIER (1987) Bank Runs as an Equilibrium Phenomenon. JPE vol. 95.

ROBERTS, JOHN (1986) Battles for Market Share: Incomplete Information, Aggressive Strategic Pricing, and Competitive Dynamics. Paper prepared for the fifth world congress of the Econometric Society.

ROMER, DAVID (1986) A Simple General Equilibrium Version of the Baumol-Tobin Model. QJE vol. CI.

ROMER, DAVID (1987) The Monetary Transmission Mechanism in a General Equilibrium Version of the Baumol-Tobin Model. JME 20.

SALONER, GARTH (1986) Predation, Mergers, and Incomplete Information. Hoover Institution WP E-86-70.

SAMUELSON, PAUL A. (1958) An Exact Consumption Loan Model of Interest with or without the Social Contrivance of Money. JPE.

SAMUELSON, PAUL A. (1968) What Classical and Neo-Classical Monetary Theory Really was. CJE.

SARGENT, THOMAS J. (1982) The Ends of Four Big Inflations. In R.E. Hall (ed.): Inflation: Causes and effects. NBER.

SARGENT, THOMAS J. - WALLACE, NEIL (1975) "Rational Expectations", the Optimal Monetary Instrument, and the Optimal Money Supply Rule. JPE.

SAVING, THOMAS R. (1976) Competitive Money Production and Price Level Determinacy. SEJ vol. 43.

SELGIN, GEORGE A. - WHITE, LAWRENCE H. (1987) The Evolution of a Free Banking System. EI.

SERLETIS, APOSTOLOS - ROBB, LESLIE A. (1986) Divisia Aggregation and Substitutability Among Monetary Assets. JMCB vol. 18.

SIDRAUSKI, MIGUEL Rational Choice and Patterns of Growth in a Monetary Economy. AER.

SIMS, GRANT E. - AKIRA, TAKAYAMA - CHAO, CHI-CHUR (1987) A Dual Approach to Measuring the Nearness of Near-Monies. RESTAT.

STARR, R.M. (1972) The Structure of Exchange in Barter and Monetary Economics. QJE.

STARR, R.M. (1980) General Equilibrium Approaches to the Study of Monetary Economics: Comments on Recent Developments. In Kareken, J. - Wallace, N. (eds.) (1980): Models of Monetary Economics, Federal Reserve Bank of Minneapolis.

SÖDERLUND, K.P. (1988) Finnish Empirical Research on the Demand for Money, in S. Honkapohja and A. Suvanto (eds.): Money, Inflation and Economic Policy. Government Printing Centre, Helsinki. Economics Department, University of Helsinki.

THE FINNISH BANKERS' ASSOCIATION (1985) "Banking Technology and Payment Flows in Finland in 1985" (in Finnish), Helsinki.

THE FINNISH BANKERS' ASSOCIATION (1986) "Payment Systems and Banking Technology in Finland", Helsinki.

TAYLOR, JOHN B. (1980a) Aggregate Dynamics and Staggered Contracts. JPE, vol. 88.

TAYLOR, JOHN B. (1980b) Output and Price Stability. JEDC.

TAYLOR, JOHN B. (1986) New Econometric Approaches to Stabilization Policy in Stochastic Models of Macroeconomic Fluctuations. Handbook of Econometrics. Ed. by Z. Griliches and M.D. Intriligator. Elsevier Science Publishers BV.

TOBIN, JAMES (1956) The Interest Elasticity of Transactions Demand for Cash. RESTAT.

WALLACE, NEIL (1980) The Overlapping Generations Model of Fiat Money. In Kareken, John - Wallace, Neil (eds.): Models of Monetary Economics, Federal Reserve Bank of Minneapolis.

VARIAN, HAL R. (1978) Microeconomic Analysis. W.W. Norton & Company, Inc.

VAUBEL, ROLAND (1977) Free Currency Competition. WWA.

VAUBEL, ROLAND (1984) The Government's Money Monopoly: Externalities of Natural Monopoly. Kyklos, vol. 37.

WEIL, PHILIPPE (1987) Confidence and the Real Value of Money in an Overlapping Generations Economy. QJE, vol. CII.

WHITE, LAWRENCE H. (1983) Competitive Money, Inside and Out. Cato Journal, vol. 3.

WHITE, LAWRENCE H. (1984) Competitive Payment Systems and the Unit of Account. AER vol. 74.

WICKSELL, KNUT (1936) Interest and Prices, 1962 Reprints of Economic Classics, Augustus M. Kelley, New York.

WILLIAMSON, STEPHEN D. (1986) Increasing Returns to Scale in Financial Intermediation and the Non-Neutrality of Government Policy. RES, LIII.

VIRÉN, MATTI (1987) Report of the Determination of Market Rates (in Finnish). Unpublished research paper.

YEAGER, LELAND B. (1983) Stable Money and Free Market Currencies. Cato Journal, vol. 3.

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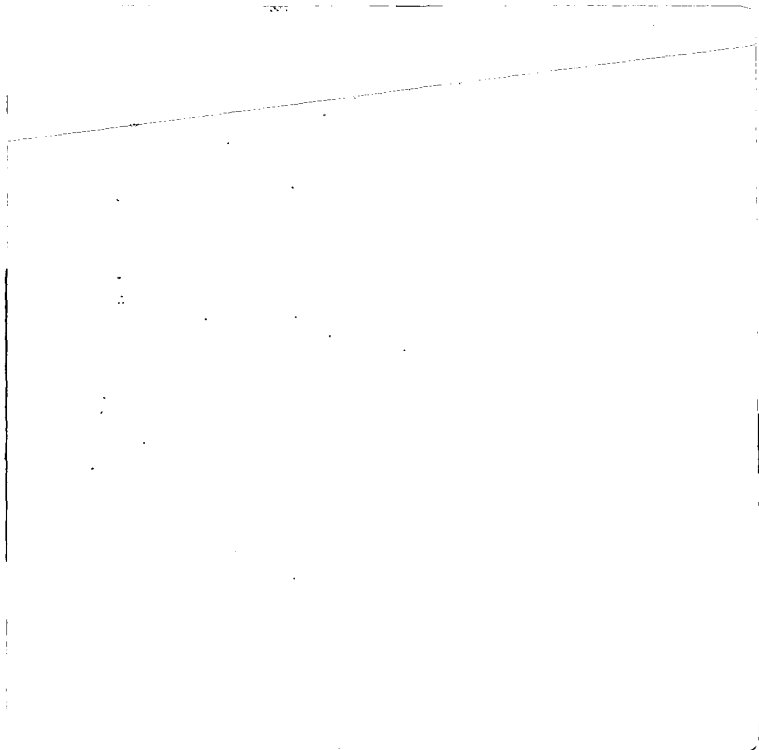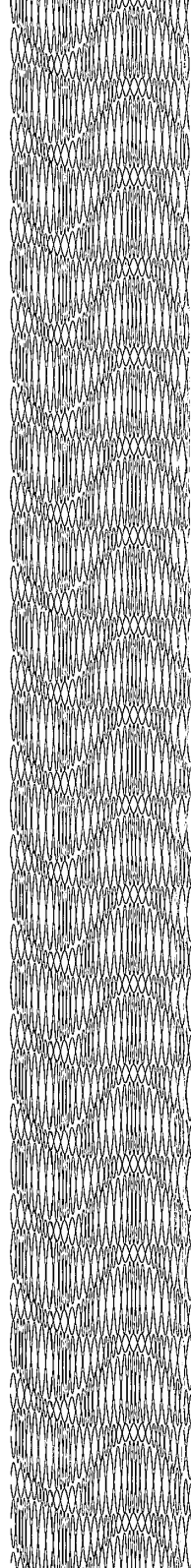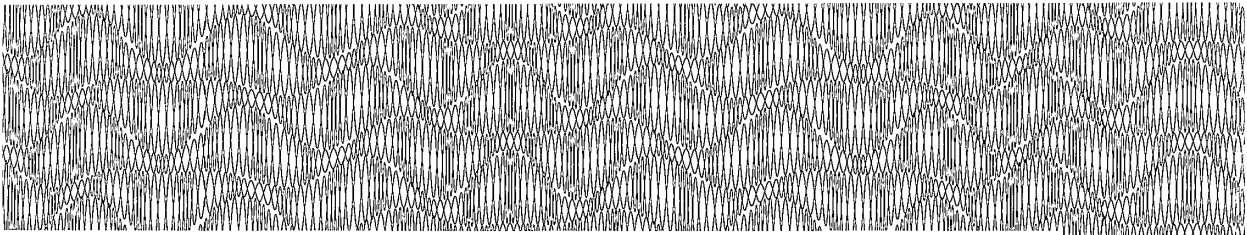70. URHO LEMPINEN - REIJA LILJA Payment Systems and the Central Bank. 1989. 210 p. (ISBN 951-686-206-3)