SIEPR Discussion Paper No. 00-01

Measuring the Inflation of Parrallel Currencies: An Empirical Reevaluation Of the Second Hungarian Hyperinflation

by

Beatrix Paal
Stanford University

June 2000

Stanford Institute for Economic Policy Research
Stanford University
Stanford, CA 94305
(650) 725-1874

June 15, 2000

Measuring the Inflation of Parallel Currencies: An Empirical Reevaluation of the Second Hungarian Hyperinflation

BEATRIX PAAL

Department of Economics, Landau Building
Stanford University, Stanford CA 94305-6072

beatrix.paal@stanford.edu

phone: (650) 724 4903
fax: (650) 725 5702

Abstract

During the hyperinflation of 1945-46, the Hungarian government issued two types of money-like liabilities with differing rates of return: a traditional non-indexed currency (called the Pengő), and an indexed central bank liability (called the Tax Pengő). In this paper I reexamine the empirical characteristics of the Hungarian hyperinflation using a definition of the money supply that includes both of these components. I argue that regulations limited the degree of substitutability between these two classes of money. This suggests a specific way of aggregating the indexed and non-indexed components of the money supply, and implies that the appropriate measure of currency depreciation is the decline in the purchasing power of this aggregate.

When the inflationary process is represented using the proposed aggregate measures, some of the empirical anomalies traditionally associated with the second Hungarian hyperinflation are readily resolved. In particular, (1) the magnitude of the inflation appears much less extreme than previously thought, (2) seigniorage income remains positive throughout the episode, and (3) unilateral Granger-causality from inflation to money creation, observed during most other hyperinflations, is verified for the entire episode.

I would like to thank seminar participants at Stanford, Texas A & M, Purdue, Haverford, UCSD, IUPUI, the Federal Reserve Banks of New York, Cleveland and San Francisco and the Board of Governors for helpful discussions. I am especially grateful for the insightful comments of Valerie Bencivenga, William Bomberger, Gail Makinen, Tom Sargent, Pierre Siklos and Bruce Smith.

1. Introduction

According to conventional wisdom, the hyperinflation that Hungary experienced following World War II exhibited by far the most severe symptoms among the famous inflations of the 20th century. In addition, findings of Cagan (1956) and of Sargent and Wallace (1973) suggest that this hyperinflation displayed many empirical features different from those associated with other hyperinflationary episodes.

Bomberger and Makinen (1980, 1983a) proposed that the extreme depreciation of the currency was generated by the government's policy of indexation. They argue that by forcing commercial banks to offer indexed deposits (denominated in the unit called Tax Pengő), the government undermined its own ability to raise seigniorage revenue from the expansion of the ordinary (Pengő) money supply. This revenue loss necessitated a faster rate of money creation and resulted in a more rapid inflation than might otherwise have occurred.

The impact of deposit indexation on the finances of the government, however, went beyond the effects described by Bomberger and Makinen (1980, 1983a). In order to help commercial banks match their indexed liabilities with indexed assets, the government allowed them to open Tax Pengő denominated accounts with the central bank. I argue that this method of subsidizing the banking sector created a second type of money-like central bank liability, one that earned a much higher rate of return than ordinary currency. At a later stage the Hungarian government also issued Tax Pengő notes. However, two different money-like government liabilities started to co-exist with the introduction of Tax Pengő deposits at the central bank.[1]

Recent econometric studies of the second Hungarian hyperinflation have focused on the Pengő denominated components of the money supply, identifying them with the traditional concept of money, and have represented indexation as a potential "regime change" which alters the demand for the non-indexed currency. Using this methodology Anderson, Bomberger and Makinen (1988) reconcile some of the paradoxical findings of Cagan (1956) and of Sargent and Wallace (1973). Siklos (1990a, 1991) distinguishes several stages of indexation within the overall period of the hyperinflation and analyzes the effects of the government's varying

[1] There were other episodes of high inflation in which multiple currencies were issued. Arnold (1937) discusses one in the context of the Russian hyperinflation, Rolnick, Smith and Weber (1994) describe another in the context of the American Revolution.

commitment to indexation. The common characteristic of these approaches is their asymmetric treatment of the non-indexed and indexed components of the money supply: the inflationary process of the non-indexed currency is modeled as being periodically altered by changes in the indexation policy.

An alternative approach, which I explore in this paper, may be to ask whether the anomalous characteristics of the Hungarian inflation largely disappear if "money" is interpreted as the entire portfolio of government liabilities that share characteristics traditionally associated with money. Liabilities satisfying this definition include not only non-indexed currency and deposits at the central bank (the conventional measure of base money), but also the indexed counterparts to these quantities. In addition to fulfilling the transaction and store of value functions of money, Tax Pengő deposits and Tax Pengő notes were also a potential source of seigniorage revenue for the government. Therefore, it is reasonable to proceed based on the notion that the demand and supply of indexed money are subject to underlying economic forces similar to those governing the demand and supply of regular, non-indexed money, and the two components can be treated symmetrically.

Two natural ways of modeling the inflation with indexed and non-indexed currencies would be either to assume separate demand functions and two supply processes for the two types of currencies, or to regard the two types of currencies as forming a composite asset, whose composition is less of interest than the demand for or the rate of return on the composite itself. In this paper I take the second approach, essentially for two reasons. First, the supply of indexed deposits and later indexed notes was not independent of the supply of non-indexed notes and deposits, and the nature of the indexation policy left the government only limited freedom to alter the composition of the money supply between the two types of liabilities. Second, the degree of substitutability between the indexed and non-indexed components of government liabilities was largely governed by government regulation of their use. These regulations were in constant change throughout the period of indexation, and the shifts in relative demand for these two components largely reflected these changes. Section 2 examines in more detail the specific policies employed during the indexation, and elaborates on these arguments.

In the presence of two types of government liabilities, special issues of aggregation have to be resolved in order to define appropriate variables for empirical analysis. Since aggregate real balances correspond to a portfolio of assets with differing rates of return, the return on this portfolio can no longer be measured by the conventionally defined inflation rate, which refers to the purchasing power of only the non-indexed component of the money supply. Instead, it is necessary to focus on the real return on the entire portfolio, which is a weighted average of the return on the two types of government liabilities. More generally, counterparts to the concepts of the nominal and real money supply, and the opportunity cost of holding real balances must be defined as index numbers, fulfilling a basic internal consistency criterion. These definitions, as well as some other issues related to the data are presented in Section 3.

The results of my calculations are grouped in two sections. Section 4 presents basic statistics about the inflation. When measured traditionally, the second Hungarian hyperinflation is far more severe than any other hyperinflation, while the amount of seigniorage generated by the government falls practically to zero towards the end of the episode. In contrast, when measured as I propose, the inflation rates during this episode, albeit extreme, are of similar order of magnitude to those observed during the German hyperinflation. Moreover, the total seigniorage raised from the two components of the money supply together remains positive and significant throughout the hyperinflation.

In Section 5 the nature of the monetary regime is investigated by repeating tests proposed by Sargent and Wallace (1973). In contrast to their findings, the pattern of unilateral Granger-causality from inflation to money creation is confirmed for the entire episode. Unlike the results of Anderson, Bomberger and Makinen (1988), this important result obtains without the introduction of regime shifts or additional conditioning regressors and without truncating the sample, indicating that Hungary II and other famous inflations exhibit much more similar co-movements between money and inflation than previously thought.

2. Government financed deposit indexation and the balance sheet of the central bank

The forces generating the Hungarian hyperinflation of 1945-46 generally conform to the well-established pattern observed in most large inflations: a government facing large expenditures and lacking substantial powers of taxation resorts to financing its budget deficit with seigniorage revenue[2]. In Hungary, the resulting process of accelerating inflation and money

---

[2] For a general historical perspective on the period see Siklos (1990b) and Bomberger and Makinen (1983a).

growth began during the prewar era of military build-up, and reached Cagan's critical mark of a 50% monthly inflation rate in August 1945. By the end of 1945, both the inflation rate and the growth rate of the money supply reached several hundred percent per month and real Pengő balances fell to a few percent of their prewar level.[3] During the first half of 1946, after the indexation policy was in effect, the depreciation of the currency continued at rates unmatched by any other inflation until the currency stabilization of August 1. The stabilization, which replaced the old Pengő with a new currency called the Forint, was apparently immediately successful at stopping the year-long hyperinflation.

The idea of indexation initially arose in the context of indexing government collections of tax revenue.[4] The government was fully aware of the underlying fiscal cause of the rapid currency depreciation, and hoped to ameliorate the situation by introducing indexed taxes. For this purpose a supposedly stable new unit of account - the Tax Pengő - was introduced on January 1, 1946. Every day an index number - the Tax Pengő Index - was calculated, which specified the value of a Tax Pengő in terms of ordinary Pengős. Taxes then were assessed in Tax Pengős, but were due in ordinary Pengős, with the actual amount owed determined by the Tax Pengő Index applicable on the day of payment. As long as the Tax Pengő Index accurately reflected the price level, the value of a Tax Pengő in fact remained constant. This method of tax collection did result in an improvement in the budgetary situation from January to March, doubling the fraction of expenditures financed by ordinary revenues from about 7% to about 14%. Starting approximately in April 1946 the Tax Pengő Index started lagging behind the actual price index, implying a depreciation of the Tax Pengő, and revenues as a percent of expenditures fell back to their earlier low levels.

The scope of indexation, however, was farther-reaching than simply the indexation of tax revenue. The same Tax Pengő unit was also introduced as a general unit of calculation for claims and liabilities. Moreover, commercial banks were obliged to denominate current and savings accounts in Tax Pengős if the depositor so desired. The requirement that commercial banks

---

[3] The monthly money growth rate and inflation rate in November were 233% and 434%, respectively, whereas real balances at the end of November were about 3.4% of the comparable 1938 figure. In December, however, the trend of the inflation was temporarily interrupted by a one-time 75% tax on currency holdings. For a description of this event, and its consequences for the inflation, see Siklos (1990b), pp. 100-102.

[4] Bresciani-Turroni (1937) discussed, in the context of the German hyperinflation, some consequences of the fact that government revenue collections were unindexed.

supply indexed deposits amounted to a high nominal interest rate floor, which was set officially on a day-to-day basis. In order to provide for the possibility that at this nominal interest rate the supply of funds might exceed the demand for funds, an outlet was provided for the excess of Tax Pengő denominated deposits over Tax Pengő denominated loans: commercial banks were allowed to deposit these excess funds in special Tax Pengő denominated accounts with the central bank.

By creating Tax Pengő denominated accounts at the central bank the government essentially issued a second type of liability, which had many of the characteristics of base money. Since these accounts were clearing accounts that commercial banks held at the central bank, payments between commercial banks could take place as transfers of balances between these accounts. More importantly, by holding deposits at one of the commercial banks, the public could indirectly hold in its portfolio Tax Pengő denominated government liabilities.

The period during which the extent of indexation was limited to deposit indexation at commercial banks might be called the first stage of indexation. A second stage started at the end of May 1946, when the government decided to also issue Tax Pengő denominated notes. This occurred in response to the serious difficulties that by this time the government encountered in trying to get the public to accept Pengő notes as payment for goods and services.

The Tax Pengő notes were issued directly by the treasury, and technically did not appear as a liability of the central bank. However, for the remaining two months of the inflation they functioned as a medium of exchange, and gradually replaced ordinary Pengő notes in cash transactions. To the extent that the ability of the treasury to directly issue Tax Pengő notes simply replaced the practice of automatic discounting of government bills by the central bank, the nature of Tax Pengő notes was hardly different from that of ordinary Pengő notes issued by the central bank. The lack of central bank independence implies that no meaningful distinction can be made between the liabilities of the treasury and the liabilities of the central bank. Thus both can simply be thought of as a liability of the "government".

In light of the above arguments it seems reasonable to define a measure of the money supply which includes both the indexed and the non-indexed components. A measure of base money in real terms can be constructed by adding to the supply of Pengő notes the Pengő and Tax Pengő denominated deposits of the public at the central bank, and later the outstanding stock of Tax Pengő notes, all expressed in real terms. The real value of the monetary base, defined in this way, as well as its distribution between its four components is illustrated in Figure 1.

What were the consequences of indexation for the money supply process, the demand for real balances and the course of the inflation?

Panel (a) of Figure 1 clearly reveals a general trend of falling real balances during the inflation. Panel (b) shows in more detail the shift over time from Pengő denominated assets to Tax Pengő denominated ones as would be expected in response to the great rate of return differential between the two. Bomberger and Makinen argue that the availability of indexed deposits at commercial banks reduced the tax base (regular Pengő notes) against which the inflation tax could be levied. This point is clearly illustrated in the figure by the declining share of the Pengő denominated components during 1946. Based on this reasoning they conjecture that "the government was theoretically returning a portion of the inflation tax to the public".[5] The existence of Tax Pengő deposits at the central bank prove this conjecture in a concrete form. A portion of the increase in the money supply was returned to the central bank and deposited in Tax Pengő denominated accounts. In Pengő terms, this amounts to the central bank paying a high nominal interest rate on these deposits, effectively rebating some of the seigniorage revenue to the holders of these accounts.

The wording of the decree which instituted the Tax Pengő denominated clearing accounts at the central bank suggests that the government did expect this operation to result in losses for the central bank. The losses, unfortunately, were never properly accounted for, since no balance sheet was prepared for the business year 1945-46. However, an idea of the extent to which the public held indexed deposits at the central bank can be obtained by comparing the Tax Pengő denominated deposits at the central bank to Tax Pengő denominated deposits at commercial banks. The ratio of these two, reported in Table 1 provides confirmation of the mechanism described by Bomberger and Makinen: a substantial fraction of the stock of indexed commercial bank deposits was not loaned out, but rather was conveniently turned into a liability of the government.[6]

---

[5] Bomberger and Makinen (1983b) p. 565.

[6] This interpretation depends on assuming that the Tax Pengő denominated current accounts at the central bank reported by the Hungarian Institute for Economic Research (1947, Part I, p. 16) are exactly the accounts of the commercial banks authorized by the January decree. Since there is no indication that any other institutions or individuals could open similar accounts at the central bank, this seems like a reasonable assumption, at least up to May 1946. However, direct confirmation on this point is lacking.

A further argument can be made, however, that concentrating exclusively on the Pengő denominated liabilities of the government reveals only one side of the story. Two key features of the data illustrated in Figure 1 give preliminary support to this claim. First, observe the relative stability of the real value of the composite portfolio of government liabilities throughout the period of indexation. Contrary to findings based on the circulation of Pengő notes alone, this suggests that the Hungarian public did not reduce its holdings of government liabilities practically to zero. Consequently the government did not entirely lose its ability to raise seigniorage revenue, as long as it managed levy the inflation tax on the indexed components of its liabilities. Second, notice that the displacement of Pengő denominated assets by Tax Pengő denominated ones was quite gradual, fully completed only by July 1946. This suggests that initially there were substantial restrictions in place that prevented people from immediately and completely reallocating their portfolios, but later these restrictions were gradually relaxed.

Next, I examine the demand and supply conditions influencing the composition of the public's holdings of government liabilities between indexed and non-indexed components. I hope to show that the relative nominal supplies of Pengő denominated base money and Tax Pengő denominated base money were not independent of the relative demand for these two assets. Moreover, the frequent institutional changes which occurred during this period imply that stable (time-invariant) demand curves for each of these components are unlikely to exist.

The first stage of indexation began on January 10, 1946 with the indexation of some deposits held at commercial banks. By committing to exchange, at least up to a certain limit, the Pengő denominated deposits of commercial banks for Tax Pengő denominated ones, the government allowed the composition of the central bank's liabilities to be influenced primarily by the demand for these liabilities. Indirect control over this composition could be affected to an extent, but only by influencing the degree of substitutability between Pengő notes/deposits and Tax Pengő deposits, and by setting their relative rate of return.

The banking structure that Hungary inherited from the prewar era consisted of two main sectors: the commercial banks belonging to the so called Central Corporation of Banking Companies, which operated mostly in the economically dominant capital and the larger cities, and the state owned Postal Savings Bank, which had branches throughout the country.[7] Initially, only

[7] Although no data is available on them during the inflation, other deposit-taking institutions were likely to be relatively insignificant. For example, in the pre-war era, deposits at the members of

the deposits at the commercial banks could be indexed, while deposits at the Postal Savings bank remained denominated in Pengős. This imposed a cost of obtaining indexed deposits on those who lived in areas where the large commercial banks did not operate, making the substitution possibilities between indexed and non-indexed assets less than perfect. The date when indexation of deposits at the Postal Savings Bank began is difficult to ascertain, but my calculations, reported in Appendix A, suggest that savings accounts were indexed from some time in May, but current accounts only from some time in July. When the various deposits at the Postal Savings Bank became indexed, the substitution possibilities between indexed and non-indexed assets improved.

The degree of substitutability between Pengő and Tax Pengő denominated assets was further influenced by the mandatory withdrawal notice period that the law set out for Tax Pengő accounts. This period was initially set at 10 days, and later reduced to 5 days. Throughout, however, the banks had little incentive to enforce this requirement. In fact, it became commonplace for individuals to deposit their Pengő notes overnight, and withdraw a scaled-up sum the next morning. Since the financial burden of this activity was borne by the central bank, a new regulation was introduced specifying that deposits into indexed accounts could be credited only the next business day, on that day's quotation of the Tax Pengő. Every time one of these changes was introduced, the substitution opportunities between Pengő and Tax Pengő changed.

The relative rate of return between the Pengő and the Tax Pengő was determined by the daily increase in the Tax Pengő Index. The rules regarding the computation of the Tax Pengő Index also changed over time.[8] Initially, the index was computed by the Hungarian Institute for Economic Research, an organization relatively independent of the government, based on prices prevailing in Budapest two days prior to the day to which the index referred. As inflation accelerated, the lag in the calculation of the index was reduced to one day.[9] Starting some time in April, the relationship between the Tax Pengő index and actual past price movements was severed, and arbitrary values, which fell short of the actual inflation rate, were applied thereafter.

---

the "Central Credit Cooperative" represented only a few percent of total deposits. See Hungarian Institute for Economic Research (1947), Part I, p. 15.

[8] See Siklos (1990b), pp. 102-110.

[9] This change, which took effect from March 1, 1946 was made possible by the fact that the rapid rate of price increases reduced the importance of changes in relative prices. Therefore, simplifying calculations by limiting the number of items sampled did not substantially worsen the quality of the index.

According to Bomberger and Makinen (1983a) this policy change took place on April 19, 1946. Siklos's calculations suggest that the change occurred around the end of April.[10]

During the second phase of indexation the government's ability to directly regulate the composition of the money supply remained weak. Had the Tax Pengő notes been issued only as payment for goods and services, their quantity could have been directly influenced. However, the previous policy of conversion on demand between Pengő and Tax Pengő deposits at the central bank was extended to notes: the public was allowed to use Pengő notes to purchase Tax Pengő notes. The conversion opportunity was limited only by the problems that arose in the printing and distribution of the Tax Pengő notes. According to the contemporary account of Ecker-Racz (1946b), the state press could only produce insufficient quantities of Tax Pengő notes, and the main distributor was regularly mobbed by crowds. These difficulties were resolved when, on July 9, 1946 the central bank took over the printing and distribution of the Tax Pengő notes.[11]

At their initial introduction, Tax Pengő notes were supposed to function just like tax anticipation notes, and were accepted by the government only for the payment of certain taxes in areas with government post offices. On June 13, their acceptability was extended to payments for public services, such as utility charges and rail fares. Starting June 23, the government began to make all its expenditures in Tax Pengős. Finally, on July 9, the Tax Pengő was declared legal tender, and all bank accounts at the Postal Savings Bank were converted to Tax Pengő denominations. The payment of taxes with Tax Pengő notes was extended to all taxes and for the whole country.

The institutional details of the indexation policy suggests that assuming independent supply processes and separate time-invariant demand functions for the Pengő and the Tax Pengő denominated components of the money supply would probably not be an accurate representation of reality. Treating the two components together as a composite asset, however brings up the following question. How does one measure inflation and currency depreciation when there are two assets that can function as money?

---

[10] See Bomberger and Makinen (1983a), fn. 14, and Siklos (1990b), Chapter 7 fn. 20 on p. 252, referring to p. 107.

[11] See Ecker-Racz (1946b), p.4. Although the central bank got involved in the technicalities of issuing Tax Pengő notes, from an accounting perspective these notes did not become part of its liabilities. In fact, the balance sheets prepared after the August 1 stabilization show the Tax Pengő note holdings of the central bank as an asset. (The Tax Pengő notes remained in circulation after the stabilization and were used as small change.) During the inflation, the note circulation figures reported by the central bank include only the Pengő notes.

After the issue of Tax Pengő notes and even after the declaration of the Tax Pengő as legal tender, the government continued to publish the Tax Pengő Index, even though by this time most non-barter transactions were conducted in Tax Pengő units. A Pengő based measure of the price level or the inflation rate could technically be obtained by multiplying Tax Pengő prices and the Tax Pengő Index, but this measure became less and less relevant over time. The portfolios of agents eventually consisted almost entirely of Tax Pengő denominated assets, and the rate of return they realized on those assets was determined by the rate at which prices, now all denominated in Tax Pengő, rose. It is hard to avoid the conclusion that at this terminal stage of the hyperinflation (in particular during the second half of July 1946), the inflation process is best thought of as the inflation of the Tax Pengő.

Since at the beginning, currency values referred to the value of the Pengő, but by the end, they referred to the value of the Tax Pengő, it is natural to try to connect these two extreme stages of the hyperinflation by a continuous path reflecting the relative monetary importance of these two liabilities. I propose to make this connection by focusing on the rate of return on an aggregate measure of real balances rather than on the inflation rate itself. The real return on a single currency naturally generalizes to the two asset case as the real return on a portfolio that is composed of indexed and non-indexed components in appropriate proportions. And, the rate of inflation – or the rate of depreciation of currency values – can be represented by the inverse of the real return on this composite portfolio. The discovery of data on the magnitude of indexed and non-indexed deposits at the central bank allows me to reconstruct the composition of the private sector's holdings of the two types of government liabilities, and calculate the rate of return on this portfolio as the average of the individual returns with weights that correspond to the portfolio shares. Section 3 explains the details of these calculations.

The hypothesis I put forward based on the descriptive evidence presented in this section is that the depreciation process of the composite of the government's monetary liabilities was subject to the same forces that acted during other hyperinflations. In this view, the government's indexation policy mattered only insofar as it affected the composition of government liabilities and the relative rate of return on their two components. Thus, the existence of indexed government liabilities might have had only a small effect on the value of the composite portfolio. If, using measures relevant for the composite portfolio, the behavior of inflation and the co-movement between inflation and an appropriately defined measure of nominal money growth seem similar to what has been found for other inflations, this can be taken as an indication in favor of the hypothesis.

3. Measurement issues

This section addresses two issues. First, I clarify some points regarding the data. Second, I describe the aggregation problems that had to be confronted in order to derive composite measures of the real and nominal money supply and the rate of return on real balances.

DATA

In order to repeat the calculations of Cagan (1956) and Sargent and Wallace (1973), monthly data is required. However, as explained below, the aggregation of the Pengő and Tax Pengő components can be improved by exploiting information contained in higher frequency raw data. Accordingly, whenever possible, I constructed data series on a biweekly frequency.[12]

In Appendix A a detailed account is given of the data sources for each variable used in the calculations. Table A.1 displays the data themselves. Here, I only briefly note those instances where I significantly departed from the established literature by using alternative data sources or interpreting existing data differently.

My data on the supply of Tax Pengő notes come from Vágó (1947). Compared to the more commonly cited data from Ausch (1958), Vágó's figures are more consistent with two additional sources, and do not imply an unreasonably high level of real holdings Tax Pengő notes at the end of May. However, while the issue of Tax Pengő notes started on May 29, Vágó's data only begins on July 9. Therefore, it was necessary to estimate the value of outstanding Tax Pengő notes during the interim period. I used linear interpolation on a daily basis between May 28 (with a hypothesized value of 0) and July 9 (with the known actual value from Vágó) to obtain these estimates at a biweekly frequency.[13]

The source of information that allows one to take account of the central bank's financing of deposit indexation is the previously unused data on clearing accounts at the central bank. The

[12] I use the word "biweekly" to designate data available on the 15th and the last day of each month. More frequent observations are available only for a few series.

[13] The data obtained in this manner is listed in Table A.1 under the heading TP notes 2. Two alternative estimates, a lower and a higher set of values, are also considered in Appendix 1.B.

figures available from the Hungarian Institute for Economic Research (1947) give the breakdown of these deposits between Pengő denominated and Tax Pengő denominated components. Reconstructing the gradual shift from Pengő to Tax Pengő in the private sector's holdings of government liabilities (as illustrated in Figure 1) is possible because of the availability of this disaggregated data.

Although I focus discussion on the demand for and supply of high-powered money, in Appendix B I also carried out calculations for a broader measure of money, which also includes savings and current account deposits at banks. Data on deposits are listed in Table A.3. I separated deposits denominated in Pengő versus in Tax Pengő by combining the data reported by the Hungarian Institute for Economic Research (1947) and the National Bank of Hungary (1947). Based on these sources, a more precise decomposition is possible than the one employed by Anderson, Bomberger and Makinen (1988), who relied on a secondary source.

AGGREGATION

Situations where the money supply can be best thought of as a combination of two assets with greatly differing rates of return are not common, and there is no generally accepted way of measuring the money supply or the rate of return on real balances under such circumstances.[14] Therefore it is worthwhile discussing the considerations that led me to the particular

[14] One approach to aggregating components of the money supply with differing rates of return has been proposed by Barnett (1980). Barnett's method is different from the method proposed here in three respects. First, Barnett advocates the use of the Theil-Törnquist index as the functional form of the index number. This is not an important difference, neither Barnett nor the analysis below proposes an underlying theory that would suggest the use of one specific index-number over another. In fact, Barnett experiments with the Fisher index as well and finds that for his data the two index number formulas yield almost identical numerical results. The second, more substantive, difference is in the definition of appropriate "nominal quantities" and "prices" to measure each component of the money supply. These different choices are implied by the difference in the theory of money that lies behind each approach. Barnett views money as providing transaction or liquidity services which appear in the utility function. In contrast, my formulation is more consistent with the financial asset view of money. Finally, my aggregation assumes that the portfolio composition of the private sector between Pengő and Tax Pengő denominated central bank liabilities is *exogenous*. By contrast, for Barnett, the composition of real balances is an equilibrium outcome responding to the nominal interest on various money components.

measurements I chose. Generally speaking, I follow the strategy advocated by Fisher and Shell (1972), and for simplicity, I think of the economy as having one good and two currencies.[15]

Let the price, in terms of the good, of the non-indexed and indexed currencies at t be denoted by pn_t, and pi_t, respectively. Let the two currencies be convertible to one-another at the "exchange rate" of x_t units of the non-indexed currency for each unit of the indexed. In actual data, x_t corresponds to the Tax Pengő Index, and pn_t and pi_t correspond to the inverse price levels measured in the two currencies. It seems to be a fairly accurate representation of the indexation system that $pi_t = pn_t \cdot x_t$.[16] Further, let the nominal quantity of the two currencies, measured in their respective units, be denoted by qn_t and qi_t.

Least problematic is the measurement of aggregate *real* balances, since non-indexed real balances and indexed real balances have the same unit of measurement (goods). Consequently, an index of the growth rate of real balances between t=1 and t=2, denoted by $\gamma^{rb}_{(1,2)}$, can be constructed as

(1) $$\gamma^{rb}_{(1,2)} = \frac{qn_2 \cdot pn_2 + qi_2 \cdot pi_2}{qn_1 \cdot pn_1 + qi_1 \cdot pi_1}$$

In the presence of two types of government liabilities, the real return on holding a composite portfolio is the weighted average of the real return on each of the components. With the notation introduced above, the gross real return between t=1 and t=2 on the non-indexed and the indexed currencies can be written as pn_2/pn_1 and pi_2/pi_1 Then, a logical measure of the average return between t=1 and t=2, $\rho_{(1,2)}$, can be defined by Fisher's "ideal index", which is the geometric mean of the Paasche and Laspeyres indices:

(2) $$\rho_{(1,2)} = \left(\frac{pn_2 \cdot qn_1 + pi_2 \cdot qi_1}{pn_1 \cdot qn_1 + pi_1 \cdot qi_1} \cdot \frac{pn_2 \cdot qn_2 + pi_2 \cdot qi_2}{pn_1 \cdot qn_2 + pi_1 \cdot qi_2} \right)^{\frac{1}{2}}$$

The Fisher index has several desirable properties relative to both the Laspeyres and the Paasche index. Most important in the present context is that the rapid portfolio reallocation towards the indexed component would make the Laspeyres index underestimate, and the Paasche index overestimate the actual rate of return. The Fisher formula strikes an average between the two.

---

[15] This approach implicitly assumes that the familiar problem of aggregation across several goods is addressed independently.

[16] In fact, the calculation of the Pengő price level after that the Tax Pengő became the dominant medium of exchange proceeded exactly based on this logic.

When only one type of money is present, it is simple to verify that the growth rate of real balances between two time periods equals the product of the nominal money growth rate and the rate of return on real balances. It is desirable to maintain this relation for the case of two currencies, i.e. to require that

$$\gamma^{rb}_{(1,2)} = \rho_{(1,2)} \cdot \gamma^{m}_{(1,2)} ,$$

where $\gamma^{m}_{(1,2)}$ is the growth rate of nominal balances between t=1 and t=2. This criterion implies that the money supply growth should also be measured as Fischer's ideal index, constructed from the nominal growth rates of the individual components:

$$(3) \qquad \gamma^{m}_{(1,2)} = \left(\frac{pn_1 \cdot qn_2 + pi_1 \cdot qi_2}{pn_1 \cdot qn_1 + pi_1 \cdot qi_1} \cdot \frac{pn_2 \cdot qn_2 + pi_2 \cdot qi_2}{pn_2 \cdot qn_1 + pi_2 \cdot qi_1} \right)^{\frac{1}{2}} .$$

Thus, the measurement of the growth rate of real and nominal balances, and of the rate of return on money can be treated a standard index-number decomposition problem, as described, for example, by Eichhorn and Voeller (1976). The only possibly counterintuitive aspect of this treatment is the fact that the usual “value index” corresponds to the index of *real* balances, and the “quantity index” to the index of *nominal* balances. Furthermore, the “price index” corresponds to the average increase in the price of the two monies in terms of the real good, i.e. the rate of return on real balances.

Fisher's index may be ideal, but it is not perfect. Notably, it fails the so called "circularity test", which would require that the rate of change from t=1 to t=3 be equal to the product of the rate of change from t=1 to t=2 and from t=2 to t=3. In the present context this failure means that

$$\rho_{(1,3)} \neq \rho_{(1,2)} \cdot \rho_{(2,3)}, \text{ and } \gamma^{m}_{(1,3)} \neq \gamma^{m}_{(1,2)} \cdot \gamma^{m}_{(2,3)} .$$

Therefore, if t=1 corresponds to the beginning, t=2 to the middle and t=3 to the end of a month, monthly measures of the rate of return on currency and the money growth rate can be constructed two different ways. On the one hand, using raw data at a monthly frequency, $\rho_{(1,3)}$ and $\gamma^{m}_{(1,3)}$ can be calculated directly. On the other hand, using raw data at the biweekly frequency, the monthly indices can be obtained as the product of two consecutive biweekly values, $\rho_{(1,2)} \cdot \rho_{(2,3)}$ and $\gamma^{m}_{(1,2)} \cdot \gamma^{m}_{(2,3)}$. The second approach can be regarded as better approximating the "true" index, because additional information is taken into account on the time path of nominal balances and rates of return between the two end-points of the period[17]. Therefore, even though my calculations ultimately require monthly data, I constructed these data as the products of appropriate biweekly values.

4. General characteristics of the inflation

Figure 2 depicts the biweekly growth rate of the money supply and the biweekly rate of return on real balances for the composite portfolio according to the definitions of the previous section. For the sake of comparison, the same statistics are also illustrated separately for the Pengő and the Tax Pengő denominated components. As would be expected, the aggregate measures show more moderate tendencies than the non-indexed component, and more explosive tendencies than the indexed component.

Examination of the composite measure indicates that the indexation experiment introduced from January 1946 was only temporarily successful in increasing the rate of return that the private sector earned on its portfolio of government liabilities. The period when the rate of return exceeded the rate of return observed during the last few months of 1945 roughly coincides with the period when ordinary tax revenues financed a larger fraction of government expenditures (January to March 1946). It appears that once the government returned to its original reliance on seigniorage revenues, the depreciation of government liabilities continued in a manner similar to that observed during 1945.

As is apparent from Figure 2, the aggregate measures proposed in this paper behave in a far less erratic manner than do the money growth rate and the rate of return on real balances when the analysis is limited to the behavior of the Pengő denominated component alone. If only the non-indexed components are taken into account, the money supply appears to dramatically fall at the same time when the price level, also measured in Pengő terms, shows its largest increase during the whole episode. When the composite portfolio is examined, the last observation on the nominal money growth rate is a large positive number. At the same time, the rate of return on real balances is at its all-time low.

[17] Since the index of real balances fulfills the circularity test, the same problem does not arise there. The "true" value of the change in real balances depends only on data at the endpoints and does not depend on the path.

Some overall numerical measures of the characteristics of the inflation are presented in Table 2, which follows the form of Table 1 of Cagan (1956). The first two columns report the results of calculations using two different definitions of the money supply: aggregate base money, and the Pengő denominated component of base money alone. My measure of M0 is composed of notes and clearing account deposits at the central bank held by the public. For the sake of easy comparison, Table 2 also repeats Cagan's results for Hungary II in column three, and as a benchmark, his results for Hungary I and Germany in columns four and five.[18]

Several rows of the original table report statistics about the rate of inflation, which is difficult to generalize to the two-asset case. Therefore, I replaced the inflation rates with two figures: the first figure gives the real return on money, which is unambiguously interpreted under both the exclusion and the inclusion of the indexed currency; the second figure gives the inverse of the first figure, and corresponds to the conventional measure of the inflation rate when only non-indexed money is included, while it represents the aggregate rate of depreciation of currency values when indexed money is also included.

Table 2 lists various measures of the "severity" of currency depreciation during the hyperinflation. Similarly to Figure 2, Table 2 also reveals a marked difference between measures relating to the aggregate versus those relating to the Pengő denominated component alone. For example, while the real rate of return on holding non-indexed currency between the beginning and the end of the inflation was on the order of 10^{-28}, the rate of return was substantially higher, on the order of 10^{-14}, for someone who held a portfolio representative of the private sector's holdings of government liabilities (row 4.a). Similarly, the nominal supply of non-indexed base money increased faster than the nominal supply of the monetary aggregate (row 5), but the difference between these two growth rates is smaller than the difference between the two rates of return. Consequently, findings that real balances fell practically to zero by July 1946 have to be interpreted with caution: the private sector's total real holdings of government liabilities remained at about 6% of their pre-hyperinflationary level, and it is only the non-indexed currency that practically disappeared in real terms (inverse of row 6).

---

[18] Appendix 1.B presents the same table for further alternative measures of the money supply. Since Cagan included in his measure (for Hungary II) the value of deposits at commercial banks, it is interesting to see how the conclusions change if M2 is used instead of M0. In addition, since the data on Tax Pengő notes is not very reliable, the calculations are repeated using two alternative estimates of this series which bracket the data used in the text. The qualitative results are robust to all these changes.

As a final interesting comparison, Figure 3 illustrates the seigniorage revenue obtained by the government from the issue of Pengő denominated base money and from the issue of both Pengő and Tax Pengő denominated base money. Clearly, the ability of the government to levy the inflation tax did not disappear with the acceleration of the inflation. Instead, seigniorage revenue raised from both assets remained above 10% of national income over the entire period of indexation.

5. The monetary regime and the money supply process

Sargent and Wallace (1973) investigated the nature of the monetary regimes in place during several hyperinflations. They contrasted two models, whose common elements are a money demand curve relating real balances (M/p) to expected inflation (π^e) according to the Cagan specification

$$\log(M_t / p_t) = -a\pi_t^e + b ,$$

and the assumption that agents form expectations regarding the future inflation rate rationally. The models differ in the description of the way monetary and fiscal policy are conducted. The first model assumes that money growth follows an auto-regressive process which is exogenous with respect to inflation. The second model is consistent with the interpretation that the government finances a fixed exogenous real deficit with seigniorage revenue. In order to maintain a constant level of revenue, the money creation process must depend on the rate of inflation. The two competing models can be tested empirically against one another by examining the direction of Granger causality between inflation and money growth. The general picture emerging from their analysis is that inflation typically "causes" money growth, whereas money growth typically does not "cause" inflation, a result consistent with the second model.

One exception to this finding is Hungary II, where causality cannot be ascertained in either direction. However, as Bomberger and Makinen (1980) pointed out, this is not surprising given that the money supply data used by Sargent and Wallace (1973), and which originated from Cagan (1956), commingled indexed and non-indexed deposits at commercial banks. The resulting empirical anomaly can partially be explained by separating out the non-indexed component of the money supply and representing indexation by one or more regime shifts, as done by Anderson, Bomberger and Makinen (1988). Their calculations quite successfully replicate the causality pattern observed during other hyperinflations when a dummy variable is included to account for the regime shift due to the introduction of the deposit indexation. However, they still have to exclude data from the end of the inflation, when indexed currency was also issued.[19]

Siklos (1990a, 1990b) also investigates the link between money and prices focusing on the Pengő note circulation alone. Using different econometric techniques, he finds that future values of money growth have significant explanatory power for current inflation throughout the episode, implying that inflation Granger-causes money creation.[20] However, Siklos also finds considerable instability in the empirical relationship, with the 1945 sample and the 1946 sample showing significant differences from each other and from the entire hyperinflationary episode, and with the possibility of even finer policy regime shifts during 1946.

The aggregate measures of nominal money growth and the rate of return on real balances defined in Section 3 can be used to repeat the Granger causality tests of Sargent and Wallace (1973).[21] Following Sargent and Wallace, the Sims form of the tests is implemented by estimating the following two equations:

$$(4) \qquad \pi_t = a_0 + a_1 \sum_{i=0}^{t-1} A^i \mu_{t-i} + a_2 A^t + a_3 \mu_{t+1} + a_4 \mu_{t+2} + a_5 t + e_t^{\pi}$$

$$(5) \qquad \mu_t = b_0 + b_1 \sum_{i=0}^{t-1} B^i \pi_{t-i} + b_2 B^t + b_3 \pi_{t+1} + b_4 \pi_{t+2} + b_5 t + e_t^{\mu},$$

where the restrictions imposed on the lag structure are necessitated by degrees of freedom considerations. The common pattern of unilateral Granger-causality from inflation to money growth is observed if based on the data the null hypothesis that in (4) $a_3 = a_4 = 0$ is rejected, but the null hypothesis that in (5) $b_3 = b_4 = 0$ cannot be rejected.

Originally, the variables μ_t and π_t represented the log first difference of the money supply and the price level, respectively. In the present context, μ_t is replaced by $\log(\gamma_t^m)$, and π_t is replaced by $-\log(\rho_t)$. This second substitution is justified by our earlier argument that the

[19] Due to a lack of degrees of freedom, further dummy variables cannot be included to capture this second possible shift.

[20] Estimates of the reverse relationship (i.e. money creation regressed on past and future inflation) are not reported, therefore the presence or absence of Granger causality from money creation to inflation is not ascertained.

[21] Unfortunately, repeating the techniques advocated by Siklos is not possible, because the aggregate data is not available at a weekly frequency.

inverse of ρ can be thought of as the generalization for the two asset case of the rate of inflation[22].

Table 3 and Table 4 report the results of estimating (4) and (5). The calculations were again carried out for the two different measures of the money supply and the rate of return on real balances already used in Table 2.[23] Correction for first-order autocorrelation in the residuals was made by estimating quasi-differenced versions of (4) and (5), using the method of Hildreth and Lu. The column labeled r contains the estimated first-order autocorrelation coefficients. As in Sargent and Wallace (1973), the values of A and B were estimated by searching within the interval (-0.99, 0.99) in steps of 0.01. For comparison, the results of Sargent and Wallace, as well as those of Anderson, Bomberger and Makinen (1988) are also recorded in these tables. The latter included a dummy variable in the equations that represented the month when indexation of deposits began. The coefficients on this dummy variable in the two equations are denoted by a_6 and b_6.

F-tests relevant for testing the null hypothesis that a_3=a_4=0, and b_3=b_4=0 are reported in Table 5. From the present calculations it is clear that the first hypothesis is rejected but the second one is not. Thus, when using the aggregate measure of the money supply and the corresponding rate of return, changes in the return to holding real balances Granger-cause money creation, but money creation does not Granger cause changes in the return to holding real balances. By contrast, when only the non-indexed component is included in the money supply, the evidence for the same one-sided causation is not favorable.[24]

6. Conclusions

In the context of the second Hungarian hyperinflation I define money as a composite asset that includes both the non-indexed and the indexed components of the government's monetary liabilities. This definition brings the empirical characteristics of this episode, which have

[22] Alternatively, equations (4) and (5) can simply be rewritten as a relationship between the real return on currency and the growth rate of the money supply. The new equations would differ from the original ones only in the sign of some of the coefficients, and inferences about the causality structure would be drawn the same way as before.
[23] Again, additional results using M2 instead of M0, alternative measures of the Tax Pengő note supply, and various truncations of the sample period are reported in Appendix B.
[24] These results are fairly robust to the changes in the data considered in Appendix B.

typically been regarded as anomalous, more into line with observations from other hyperinflations. More specifically, the magnitude of inflation becomes similar to that observed during the German hyperinflation, seigniorage revenue remains positive throughout the entire period, and the Granger causality structure of the data exhibits the unilateral feedback from inflation to money creation which is typical of other episodes.

My results give some support to the hypothesis that the aggregate portfolio of government liabilities and the rate of return on that portfolio was subject to the same influences that operated during other hyperinflations. The most important of these factors is the government’s budgetary situation. In addition, I am tempted to interpret the depreciation of aggregate government liabilities as what might have happened to the ordinary currency had indexed government liabilities not been issued. In this sense, the difference between the magnitude of the inflation as measured using Pengő denominated units alone, and its features as measured by the depreciation of the composite portfolio, can be viewed as being due to the indexation policy. Under this interpretation, the calculations of this paper are helpful in gauging the degree to which the indexation was responsible for the severity of the inflation, and suggest that indexation explains a substantial part of the apparent difference between the second Hungarian and other hyperinflations. However, it appears that even in absence of deposit indexation, the hyperinflation would have been extremely severe.

When evaluating the general implications of my findings for the desirability of some form of indexation of financial assets under inflationary circumstances, it is important to make a distinction between the indexation of private liabilities (inside money) versus government liabilities (outside money). In Hungary, deposit indexation accelerated the depreciation of the non-indexed currency, largely because of its direct effect on the government's budget constraint. This effect was due to the subsidization of the banking sector and the associated issue of indexed *government* liabilities. In other instances, if only inside money is indexed but outside money is not, one would not expect the consequences to be the same.

References

Anderson, Robert B., Bomberger, William E. and Makinen, Gail E. (1988). The demand for money, the "reform effect" and the money supply process in hyperinflations. *Journal of Money, Credit and Banking,* **20(4)**, pp. 653-672.

Arnold, Arthur Z. (1937). *Banks, Credit and Money in Soviet Russia*. New York: Columbia University Press.

Ausch, Sandor (1958). *Az 1945-46. evi inflacio es stabilizacio* [The inflation and stabilization of 1945-46]. Budapest: Kossuth.

Barnett, William A. (1980). Economic monetary aggregates. *Journal of Econometrics*, **14**, pp. 11-48.

Barro, Robert J. (1970). Inflation, the payments period and the demand for money. *Journal of Political Economy,* **78**, pp. 1228-1263.

Bomberger, William A. and Makinen, Gail E. (1980). Indexation, inflationary finance and hyperinflation: The 1945-1946 Hungarian experience. *Journal of Political Economy*, **88(3)**, pp. 550-560.

Bomberger, William A. and Makinen, Gail E. (1983a). The Hungarian hyperinflation and stabilization of 1945-1946. *Journal of Political Economy*, **91(5)**, pp. 801-824.

Bomberger, William A. and Makinen, Gail E. (1983b). Some further thoughts on the Hungarian hyperinflation of 1945-46. *The South African Journal of Economics*, **51(4)**, pp. 741-750.

Bresciani-Turroni, Constantino (1937). The Economics of Inflation: *A Study of Currency Depreciation In Post-War Germany.* London: Allen and Unwin.

Cagan, Phillip (1956). The monetary dynamics of hyperinflation. In: *Studies in the Quantity Theory of Money,* ed.: Milton Friedman, pp. 25-117. Chicago: The University of Chicago Press.

Ecker-Racz, Laszlo (1946a). *Hungarian Economic Developments: January 1945 – June 1946.* Budapest: American Legation.

Ecker-Racz, Laszlo (1946b). *The Hungarian Currency Stabilization*. Budapest: American Legation.

Eichhorn, Wolfgang and Voeller, Joachim (1976). *Theory of the Price Index: Fisher's Test Approach and Generalizations*. Berlin: Springer Verlag.

Fisher, Irving (1922). *The making of Index Numbers*. New York: Houghton Mifflin.

Fisher, Franklin M. and Shell, Karl (1972). *The Economic Theory of Price Indices: Two Essays on the Effects of Taste, Quality and Technological Change*. New York: Academic Press.

Hungarian Institute for Economic Research (1947). A Magyar Gazdasagkutato Intezet gazdasagi helyzetjelentese [Bulletin of the Hungarian Institute for Economic Research], Vol. 54. (in Hungarian with English summaries and table headings). Budapest: Magyar Gazadasagkutato Intezet.

National Bank of Hungary (1947). *Hungary in Statistical Tables*. Budapest: National Bank of Hungary.

Rolnick, Arthur J., Smith, Bruce D. and Weber, Warren E. (1994). The origins of the monetary union in the United States. In: *Varieties of Monetary Reforms: Lessons and Experiences on the Road to Monetary Union,* ed.: Siklos, Pierre L. Boston: Kluwer.

Salemi, Michael K. and Sargent, Thomas J. (1979). The demand for money during hyperinflations under rational expectations: II. *International Economic Review*, **20(3)**, pp. 59-82.

Sargent, Thomas J. (1976). Econometric exogeneity and alternative estimators of portfolio balance schedules for hyperinflations. *Journal of Monetary Economics,* **2**, pp. 511-521.

Sargent, Thomas J. (1977). The demand for money during hyperinflations under rational expectations: I. *International Economic Review*, **18(1)**, pp. 59-82.

Sargent, Thomas J. and Wallace, Neil (1973). Rational expectations and the dynamics of hyperinflation. *International Economic Review*, **14(2)**, pp. 328-350.

Siklos, Pierre L. (1990a) The link between money and prices under different policy regimes: The postwar Hungarian experience. *Explorations in Economic History*, **27**, pp. 468-482.

Siklos, Pierre L. (1990b) *War Finance, Reconstruction, Hyperinflation and Stabilization in Hungary: 1938-1948*. New York: McMillan and St. Martin’s Press

Siklos, Pierre L. (1991) The money growth-inflation relationship under hyperinflation: an illustration from Hungary’s postwar experience. *Applied Economics,* **23**, pp. 1453-1460.

Vago, Jozsef (1947). *Inflacio – Stabilizacio.* [Inflation – Stabilization.] in: Magyar Gazdasagi Evkonyv [Hungarian Economic Yearbook], ed.: Kugyi-Viragh, Laszlo. Budapest: Hungaria Hirlapnyomda.

Tables and figures

Table 1
The ratio of Tax Pengő deposits at the central bank to Tax Pengő deposits at commercial banks.

Jan-46	Feb-46	Mar-46	Apr-46	May-46	Jun-46	Jul-46
67%	77%	76%	58%	66%	53%	81%

Source: Calculated from Table A.1 and Table A.3.

Table 2
General characteristics of the hyperinflation.

	Aggregate measures for Hungary II		Cagan's results		
	M0, P&TP	M0, P only	Hungary II	Hungary I	Germany
1. Beginning month	Aug. 1945	Aug. 1945	Aug. 1945	Mar. 1923	Aug. 1922.
2. Ending month	Jul. 1946	Jul. 1946	Jul. 1946	Feb. 1924	Nov. 1923
3. Number of months	12	12	12	10	16
4.a. Real rate of return on money from beginning to end	$1.932\cdot10^{-14}$	$1.924\cdot10^{-28}$	$2.62\cdot10^{-28}$	$2.27\cdot10^{-2}$	$9.80\cdot10^{-11}$
4.b. Ratio of prices at end to beginning	$5.175\cdot10^{13}$	$5.196\cdot10^{27}$	$3.81\cdot10^{27}$	$4.40\cdot10^{1}$	$1.02\cdot10^{10}$
5. Ratio of quantity of money at end to beginning	$2.868\cdot10^{12}$	$2.389\cdot10^{15}$	$1.19\cdot10^{25}$	$1.70\cdot10^{1}$	$7.32\cdot10^{9}$
6. Ratio of (4b) to (5)	18.05	$2.175\cdot10^{12}$	320	2.59	1.40
7.a. Average real rate of return on money (per month)	$7.197\cdot10^{-2}$	$4.902\cdot10^{-3}$	$5.03\cdot10^{-3}$	$6.85\cdot10^{-1}$	$2.37\cdot10^{-1}$
7.b. Average rate of rise in prices (per month)	1,289%	20301%	19,800%	46.0%	322%
8. Average rate of rise in quantity of money (per month)	992%	1812%	12200%	32.7%	314%
9. Ratio of (7b) to (8)	1.300	11.203	1.62	1.41	1.03
10. Month of minimum real return on money	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1923	Oct. 1923
11.a. Minimum monthly real return on money (per month)	$2.983\cdot10^{-5}$	$7.723\cdot10^{-15}$	$2.38\cdot10^{-15}$	$5.05\cdot10^{-1}$	$3.07\cdot10^{-3}$
11.b. Maximum monthly rise in prices (per month)	$3.572\cdot10^{6}$%	$1.295\cdot10^{16}$%	$4.19\cdot10^{16}$%	98.0%	$3.24\cdot10^{4}$%
12. Change in quantity of money in month in row 10. (per month)	$3.352\cdot10^{6}$%	$7.096\cdot10^{5}$%	$1.03\cdot10^{15}$%	46.0%	$1.30\cdot10^{3}$%
13. Ratio of (11b) to (12)	1.066	$1.825\cdot10^{10}$	40.7	2.13	24.9
14. Month in which real value of money was lowest	Jun. 1946	Jul. 1946	Jul. 1946	Feb. 1924	Oct. 1923
15. Ratio real value of money in row 14. to value at beginning	0.05275	$4.598\cdot10^{-13}$	$3.1\cdot10^{-3}$	0.39	0.030

Table 3
Inflation regressed on money creation: equation (4).

Money measure	Date	a_0	a_1	a_2	A	a_3	a_4	a_5	a_6	r	D.W.
Aggregate measures for Hungary II											
M0, P&TP	Jun-45	5.2718	1.1864	-7.1554	0.76	1.3074	-0.6484	-0.7597	—	-0.9339	3.04
	May-46	(0.2927)	(0.0794)	(0.4332)		(0.1114)	(0.0569)	(0.0445)			
M0, P only	Jun-45	0.2620	1.8975	-7151.6814	-0.01	-0.1203	-0.1787	-0.0319	—	-0.9843	1.96
	May-46	(0.2262)	(0.4123)	(4884.7741)		(0.1818)	(0.0657)	(0.0456)			
Anderson, Bomberger and Makinen (1988)											
P notes	Jun-45	-0.434	1.124	-0.288	-0.89	0.668	-0.684	0.181	-0.947	-0.54	...
	Mar-46	(0.015)	(0.059)	(0.301)		(0.041)	(0.012)	(0.004)	(0.028)		
Sargent and Wallace (1973)											
P notes,	Sep-45	3470.5169	1.1459	-3435.7382	0.99	1.6519	-0.6487	-35.4153	—	-0.6612	3.09
P&TP deposits	May-46	(610.6772)	(0.3285)	(604.9208)		(0.3336)	(0.1426)	(6.0521)			

notes: standard errors in parenthesis

Table 4
Money creation regressed on inflation: equation (5).

Money measure	Date	b_0	b_1	b_2	B	b_3	b_4	b_5	b_6	r	D.W.
Aggregate measures for Hungary II											
M0, P&TP	Jun-45	-0.5306	0.3052	17.2617	0.26	0.1135	0.0714	0.0794	—	-0.1717	2.38
	May-46	(0.2211)	(0.1262)	(10.6903)		(0.1574)	(0.0760)	(0.0336)			
M0, P only	Jun-45	-0.4076	0.3140	19.4607	0.22	0.0858	0.0452	0.0726	—	-0.2197	2.35
	May-46	(0.1841)	(0.1038)	(12.7946)		(0.1297)	(0.0446)	(0.0248)			
Anderson, Bomberger and Makinen (1988)											
P notes	Jun-45	174.66	0.212	-172.818	0.99	0.265	-0.050	-1.733	-0.691	-0.95	...
	Mar-46	(383.86)	(0.192)	(379.820)		(0.079)	(0.132)	(3.851)	(2.543)		
Sargent and Wallace (1973)											
P notes,	Sep-45	-1.6880	0.6186	1.2515	0.34	0.1366	-0.0307	0.2545	—	-0.4339	3.30
P&TP deposits	May-46	(0.6663)	(0.1673)	(0.6138)		(0.1066)	(0.0378)	(0.0735)			

notes: standard errors in parenthesis.

Table 5
F-statistics for testing joint significance of future values of the independent variable.

Money supply measure	Date		(4) π regressed on μ	(5) μ regressed on π	Degrees of freedom	Critical values of F	
						p=0.05	p=0.01
Aggregate measures for Hungary II							
M0, P&TP	Jun-45	May-46	71.72	5.60	5	5.79	13.27
M0, P only	Jun-45	May-46	6.62	11.49	5	5.79	13.27
Anderson, Bomberger and Makinen (1988)							
P notes	Jun-45	Mar-46	967.49	3.89	2	19.00	99.00
Sargent and Wallace (1973)							
P notes, P&TP deposits	Sep-45	May-46	<1	<1	2	19.00	99.00

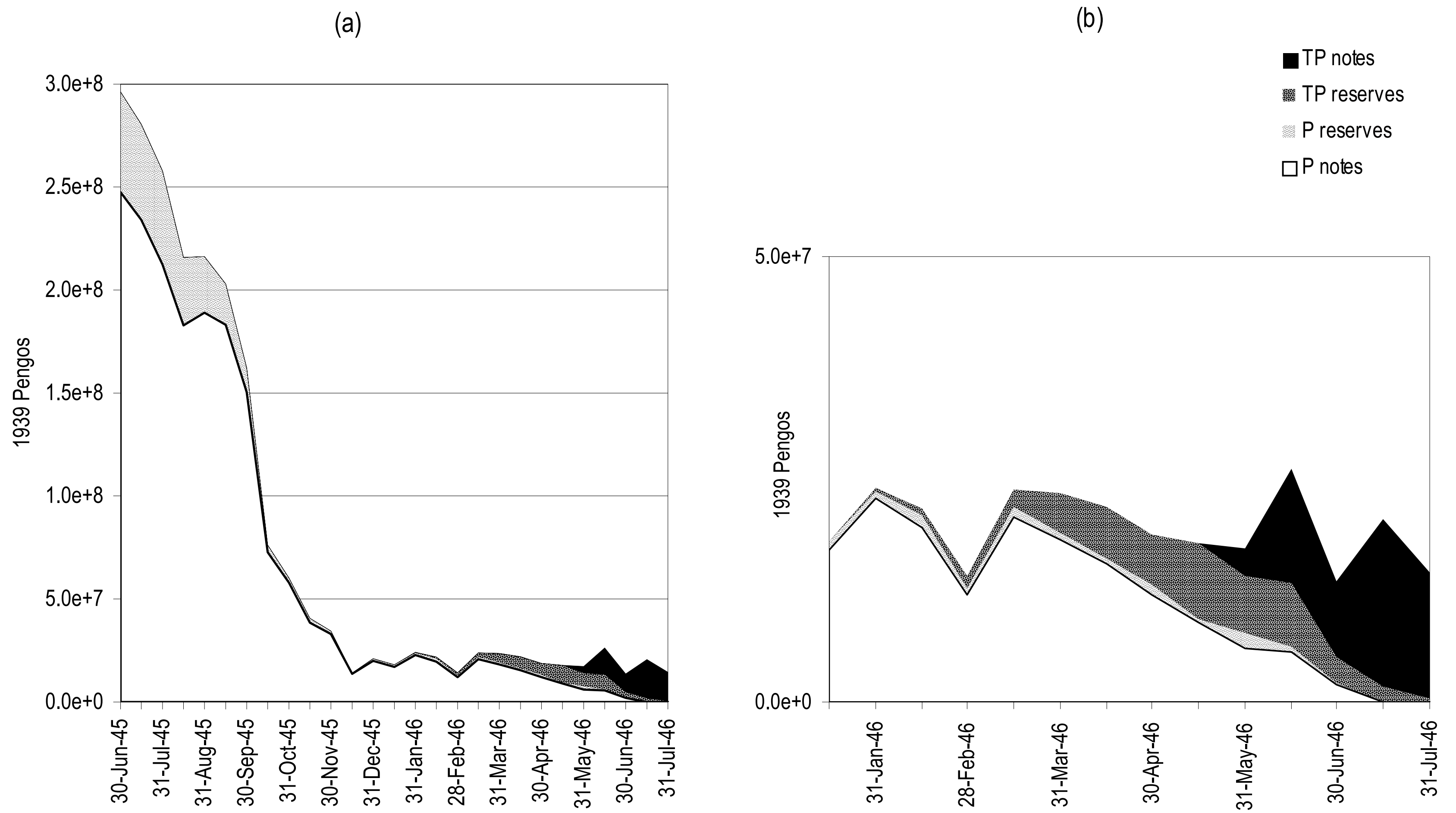


Figure 1
Real value of the components of base money (biweekly).

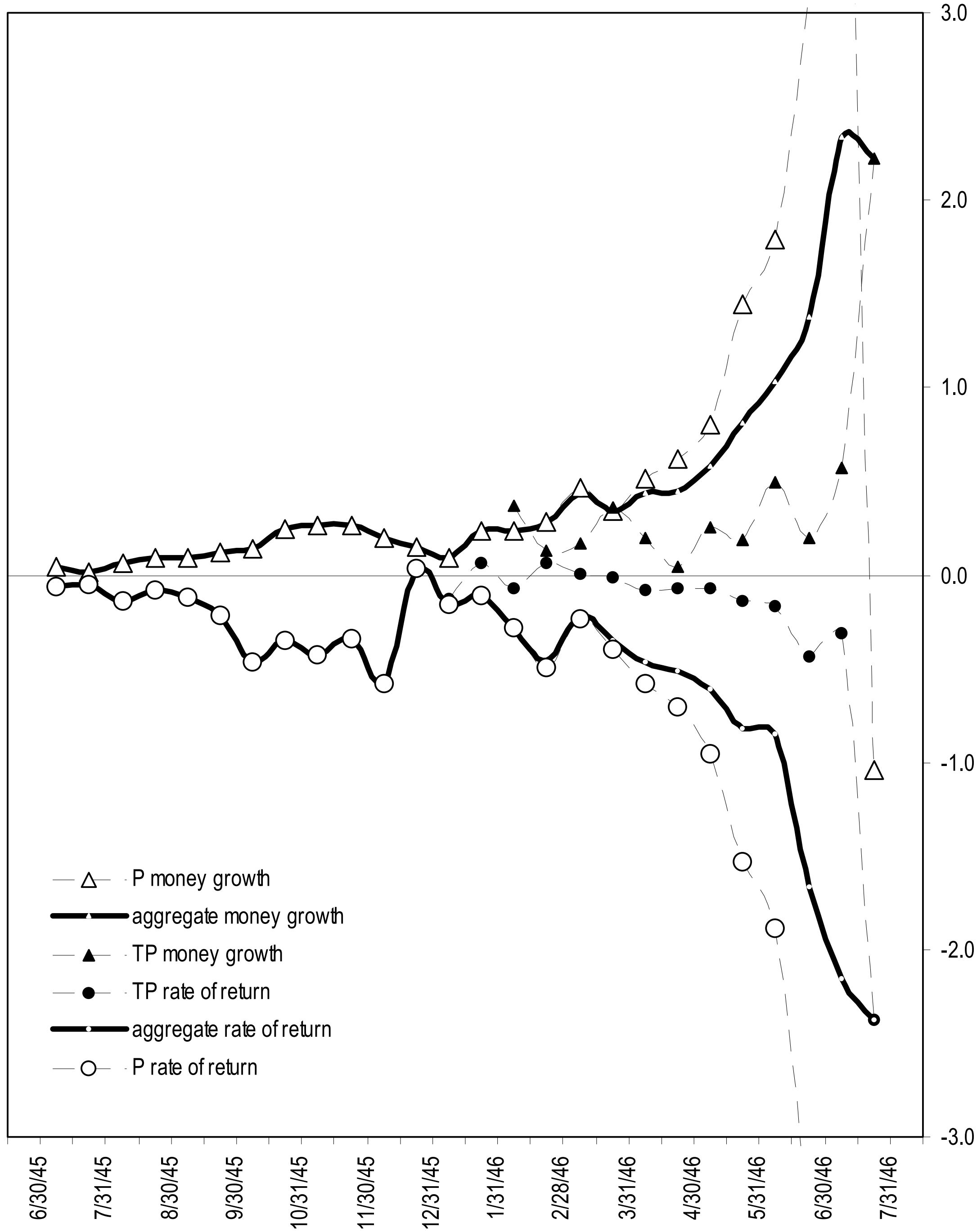
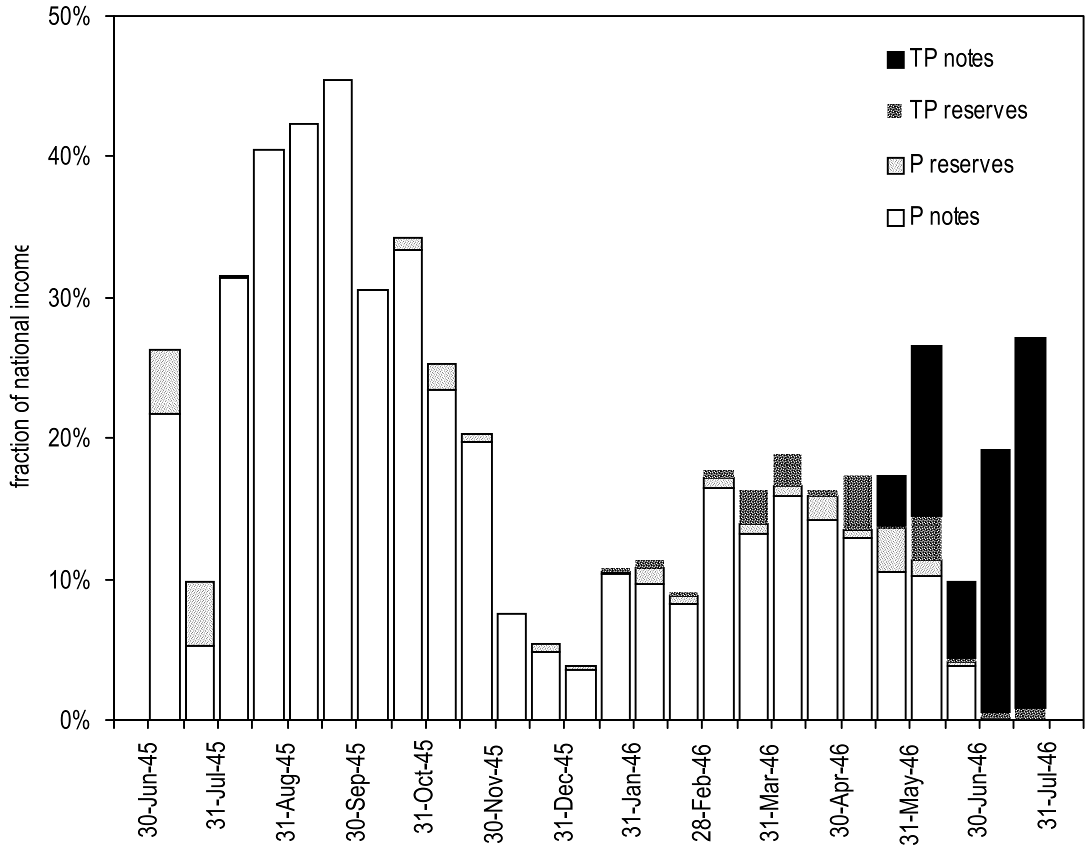


Figure 2
Growth rate of the money supply and the rate of return on real balances (biweekly).



Note: Bomberger and Makinen (1983) cite a national income estimate of 2,541 million Pengős for 1945-46 in 1936-39 prices. Seigniorage revenue was calculated as $(M_{t+1}-M_t)/((p_{t+1}+p_t)/2)$ and scaled by 1/24th of yearly national income.

Figure 3
Seigniorage revenue from the issue of base money (biweekly).

Appendix A

This appendix reviews the sources of the data on the components of the monetary base, the price level and the Tax Pengő Index. The highest frequency at which all of these series are available is two observations per month. (The 15th and the last day of the month. For short, I call this frequency "biweekly".) Therefore, Table A.1 lists the data only at this frequency, even though some of the series might exist at higher frequencies. In order to provide further comparison with the results of Cagan (1956) and Sargent and Wallace (1973), some of the calculations of the text are repeated for a broader measure of the money supply in Appendix 1.B. For this, data on bank deposits is also necessary. Sources for deposit data, which are only available at a monthly frequency, are also reviewed, and the data themselves are presented in Table A.3. Finally, the method of constructing aggregate measures of money growth and currency depreciation is illustrated in Table A.6.

THE MONETARY BASE

Pengő money supply data on a basis of four observations per month are available, starting in July 1945, from Siklos (1990b, Table W.1, pp. 199-207). These data are derived from internal weekly reports of the central bank. Prior to this time, money supply figures are only reported on a monthly basis. (Siklos, 1990b, Table M.1, pp. 212-219). In order to make the two sources compatible with each other and obtain the series listed in Table A.1, it was necessary to exclude from the higher frequency data a sum of $9.1106 \cdot 10^9$ Pengős. This amount was removed from the country late 1944 or early 1945 by retreating Hungarian Nazis. Apart from the inclusion/exclusion of the removed notes, the data reported in these and other sources -- the bulletin of the Hungarian Institute for Economic Research (1947) and the Monthly Bulletin of the National Bank of Hungary (various issues) -- show only minor discrepancies[25].

[25] The Hungarian Institute for Economic Research (1947, Part I, p.17, fn. 3.) warns that the accounting procedures of the central bank did not properly reflect the effect on the money supply of the 75% tax on the note circulation imposed on December 19, 1945. Therefore, the figures from December 23, 1945 to January 31, 1946 overstate the actual note circulation, the proper value of which on December 31, 1945 was probably between 200-300 million P, instead of the official figure of over 750 million. For lack of more precise data, however, I did not correct for this problem.

Data on the supply of Tax Pengő notes is more difficult to construct. A summary of the various primary sources is provided in Table A.2. The data reported by both Bomberger and Makinen (1983a) and Siklos (1990b) come from the same underlying source, Ausch (1958). The conversion of Ausch's nominal quantities to real values suggests that the interpretation of the reported figures as the outstanding note supply may be incorrect. Unfortunately Ausch's wording is imprecise, and the source of his data is not mentioned, but the order of magnitude of the figure taken as the Tax Pengő supply on May 29, 1946 seems to be too high in face of some reports about initial difficulties encountered in printing and distribution. The amount of $4.45 \cdot 10^{12}$ Tax Pengős corresponds, at the May 31 Tax Pengő Index of $1.08 \cdot 10^{5}$, to over seven times the end of May ordinary Pengő supply of $6.56 \cdot 10^{16}$, a seemingly excessive amount for the day of the introduction of the Tax Pengő notes.

An alternative source, Vágó (1947), reports figures similar to those in Ausch (1958), but with a different timing of issues. Two other independent sources, the Hungarian Institute for Economic Research (1947) and Ecker-Racz (1946a), suggest that the first two lines of Vágó's figures are best interpreted as flows over the respective periods, and this is the interpretation that I adopted. Regarding the figure for July 23, I chose the value reported by Vágó over the one reported by Ecker-Racz, because Vágó's figure also coincides with Ausch's. Multiple sources indicate that the end of July Tax Pengő circulation was between $2.58 \cdot 10^{15}$ and $2.8 \cdot 10^{15}$, consequently I accepted Vágó's estimate here too.

Unfortunately, accepting Vágó's figures for the Tax Pengő money supply implies that the data corresponding to May and June is missing. I used linear interpolation on a daily basis between May 28 (with a hypothesized value of 0) and July 9 (with the known actual value from Vágó) to estimate these values. The resulting data is reported in the column labeled "TP notes 2" in Table A.1. Lack of an obvious better alternative motivated this choice of linear interpolation, even though the assumption of exponential growth would be more natural. First, using log-linear extrapolation backwards from the post-July-9 data is difficult to justify, because the time series on the nominal supply of Tax Pengős is likely to have a break on July 9. On this date, the Tax Pengő was declared legal tender, and during the month of July, its depreciation accelerated enormously. Second, using log-linear interpolation between some starting date and July 9 would require the existence of a positive nominal value on the starting date, which is not available from Vágó's data. These two alternative methods were nevertheless implemented, (the second one by using Ausch's data), and the resulting data are reported as "TP notes 1" and "TP notes 3", respectively, in Table A.1. Since these two alternatives conveniently bracket the estimates used in the main text, they are used in Appendix 1.B to examine the robustness of the results to the assumptions regarding the data on the Tax Pengő note supply.

Data on clearing accounts held by the public at the central bank are available from the Hungarian Institute for Economic Research (1947, Part I, pp. 16-17) at a frequency of two observations per month, starting on September 30, 1945, and from the National Bank of Hungary (1947, pp. 30-31), at a monthly frequency, starting on July 31, 1945. The two sources show only minor discrepancies. For the period April-June I estimated the data by log-linear interpolation between the last available figure on November 1944, and the first available figure on July 31, 1945. The resulting values are listed as Pengő reserves in Table A.1.[26]

The reporting of Tax Pengő denominated clearing accounts starts on January 31, 1946. Since the deposit indexation began on January 10, it is reasonable to assume that on January 15, the Tax Pengő denominated reserves at the central bank were either not set up yet, or were of small magnitude. The data for July 31, 1946 is reported only as an appropriately converted sum of Pengő and Tax Pengő reserves, which I attributed entirely to the Tax Pengő component, because it appears that by this time all financial assets were indexed. The resulting data is shown as Tax Pengő reserves in Table A.1.

THE PRICE LEVEL AND THE TAX PENGŐ INDEX

For price level data I used the cost of living index, including rent, as reported by Siklos (1990b, Table W.1, pp. 199-207). To my knowledge, this is the only series which spans the entire episode and is reported at the same frequency as the Pengő note supply figures. Some of the elements in this series were estimated by Siklos since the underlying source had missing observations or reported figures for slightly different dates. For these adjustments, see the notes following his table.

The Tax Pengő Index, which expresses the value of a Tax Pengő in terms of a regular Pengő (in levels), is available on a daily basis for January 2 to July 29, 1946, except on Sundays and holidays. The differences between the alternative primary sources -- National Bank of Hungary (1946), Hungarian Statistical Yearbook, Ecker-Racz (1946b, p. 109.) -- are small, and

[26] In an earlier version of this paper I used a more crude method of estimating reserves. I would like to thank Professor Pierre Siklos for pointing out that my assumptions there might have been too strong. The improved estimates in this paper are, in fact, numerically quite different from the data I used earlier. However, the qualitative results of the calculations are unaffected.

do not affect the figures used in this paper. It was necessary to impute a value for December 31, 1945, and for July 31, 1946. I took the December 31 value to be 1.000, which is the actual value on January 2, and the July 31 value to be $2.000 \cdot 10^{21}$, which is both the last reported value on July 29, and the ratio of the Forint/Pengő conversion rate ($4 \cdot 10^{29}$) to the Forint/Tax Pengő conversion rate ($2 \cdot 10^{8}$). Both this series and the price index data are listed in Table A.1.

BANK DEPOSITS

Detailed data on bank deposits is reported in two primary sources -- the Hungarian Institute for Economic Research (1947, p. 15), and from the National Bank of Hungary (1947, p. 28). The two main groups of institutions, from which deposit data are available, are the large commercial banks belonging to the Central Corporation of Banking Companies (CCBC), and the branches of the Postal Savings Bank (PSB). Table A.3 displays the deposit data broken down between these institutions and between balances of savings and current accounts. Below I describe the procedure by which I compiled these data from the two primary sources.

During 1945, while bank deposits were not indexed, there are only minor differences between the two sources. Figures for a period which includes April and May 1945 are not available for the CCBC, but deposit data at the PSB is available continuously. Since the ratio of deposits at the CCBC to deposits at the PSB appears to be relatively stable both before and after this gap, I estimated savings deposits at the CCBC as 230%, and current account deposits as 300% of the corresponding figures at the PSB.

With the introduction of deposit indexation at commercial banks in January 1946, Pengő denominated and Tax Pengő denominated deposits started to co-exist. Table A.4 and Table A.5 compare the data available from the two primary sources on deposits at the CCBC and the PSB, respectively.

The Hungarian Institute for Economic Research (1947, p. 16) reports the value of bank deposits at the CCBC separately for accounts kept in Pengő denominated and those kept in Tax Pengő denominated form. Unfortunately, these numbers do not refer to the last day of each month, the day for which data on the note circulation is available. With nominal quantities rising very rapidly during the hyperinflation, the few days of difference in the reporting would make the two series incomparable. On the other hand, the figures reported by the National Bank of Hungary (1947, p. 28), do relate to the last day of the month, but are not disaggregated between the Pengő and the Tax Pengő components. Notice that these figures are similar to the total Pengő value of indexed and non-indexed deposits calculated from the Hungarian Institute for Economic Research data. I accepted the interpretation that the discrepancy between the two sources resulted from the different reporting day, and made the assumption that the real composition of deposits between Pengő and Tax Pengő denominated components did not change very much during the last few days of the month. Therefore, I could obtain disaggregated deposit data for the last day of each month by distributing the total Pengő value of deposits on the last day of the month (available from the National Bank of Hungary) in proportion to the real shares of the Pengő and the Tax Pengő components (calculated from the Hungarian Institute for Economic Research data).

In the case of the PSB, data on Tax Pengő denominated accounts is not available directly. Various sources suggest that indexation of deposits at the Postal Savings bank was started later than at commercial banks. This is consistent with the interpreting the data available from the Hungarian Institute for Economic Research as the value of Pengő denominated deposits, and interpreting the data from the National Bank of Hungary as the total value of both types of deposits expressed in terms of Pengős. In addition, it appears that the problem of different reporting days is not present. Using these assumption, the discrepancy between the two sources can be viewed as the value of Tax Pengő denominated deposits at the PSB. Thus, indexation of savings accounts at the PSB started in May, while current accounts were not indexed even in June.

Finally, during July 1945, data on Pengő denominated accounts at the PSB and Pengő denominated savings accounts at the CCBC is missing. It is reasonable to assume that at this time all these accounts were denominated in Tax Pengő units, and only a small fraction of current accounts at the CCBC was still in Pengő units.

To illustrate that my procedure for separating indexed and non-indexed deposits results in reasonable data, Figure 1.A.1 plots the composition of the real value of bank deposits. Clearly, the value of Tax Pengő denominated deposits gradually overtakes the value of Pengő denominated deposits. In addition, the share of deposits at the PSB is declining while deposits there are not indexed. This trend is reversed when indexation is extended first to savings and later to current accounts at the PSB.

AGGREGATE MEASURES

The construction, from biweekly data, of monthly aggregate measures of the growth rate of the money supply and the rate of return on real balances is illustrated in Table A.6. These data correspond to defining the money supply as the monetary base, including the Pengő and Tax Pengő denominated notes and reserves, i.e. the data used in the calculations of the main text. The equivalent measures for alternative definitions of the money supply can be constructed similarly.

Table A.1
Data on the monetary base, the price level and the Tax Pengő Index.

Date	P notes	TP notes 1	TP notes 2	TP notes 3	P reserves	TP reserves	P price[1]	TP Index
30-Apr-45	$1.164\cdot10^{10}$				$1.892\cdot10^{9}$		$5.835\cdot10^{1}$	
15-May-45							$5.837\cdot10^{1}$	
31-May-45	$1.210\cdot10^{10}$				$2.322\cdot10^{9}$		$5.840\cdot10^{1}$	
15-Jun-45							$5.842\cdot10^{1}$	
30-Jun-45	$1.446\cdot10^{10}$				$2.850\cdot10^{9}$		$5.845\cdot10^{1}$	
15-Jul-45	$1.592\cdot10^{10}$				$3.158\cdot10^{9}$		$6.800\cdot10^{1}$	
31-Jul-45	$1.632\cdot10^{10}$				$3.499\cdot10^{9}$		$7.690\cdot10^{1}$	
15-Aug-45	$1.937\cdot10^{10}$				$3.501\cdot10^{9}$		$1.060\cdot10^{2}$	
31-Aug-45	$2.441\cdot10^{10}$				$3.504\cdot10^{9}$		$1.291\cdot10^{2}$	
15-Sep-45	$3.111\cdot10^{10}$				$3.396\cdot10^{9}$		$1.700\cdot10^{2}$	
30-Sep-45	$4.192\cdot10^{10}$				$3.292\cdot10^{9}$		$2.788\cdot10^{2}$	
15-Oct-45	$5.967\cdot10^{10}$				$2.845\cdot10^{9}$		$8.210\cdot10^{2}$	
31-Oct-45	$1.069\cdot10^{11}$				$4.045\cdot10^{9}$		$1.845\cdot10^{3}$	
15-Nov-45	$1.911\cdot10^{11}$				$1.070\cdot10^{10}$		$4.958\cdot10^{3}$	
30-Nov-45	$3.555\cdot10^{11}$				$1.464\cdot10^{10}$		$1.075\cdot10^{4}$	
15-Dec-45	$5.632\cdot10^{11}$				$1.593\cdot10^{10}$		$4.133\cdot10^{4}$	
31-Dec-45	$7.654\cdot10^{11}$				$4.210\cdot10^{10}$		$3.848\cdot10^{4}$	$1.000\cdot10^{0}$
15-Jan-46	$9.425\cdot10^{11}$				$5.759\cdot10^{10}$	$0.000\cdot10^{0}$	$5.553\cdot10^{4}$	$1.080\cdot10^{0}$
31-Jan-46	$1.646\cdot10^{12}$				$6.327\cdot10^{10}$	$1.805\cdot10^{10}$	$7.226\cdot10^{4}$	$1.640\cdot10^{0}$
15-Feb-46	$2.722\cdot10^{12}$				$2.034\cdot10^{11}$	$4.220\cdot10^{10}$	$1.396\cdot10^{5}$	$2.710\cdot10^{0}$
28-Feb-46	$5.238\cdot10^{12}$				$3.612\cdot10^{11}$	$5.750\cdot10^{10}$	$4.359\cdot10^{5}$	$9.850\cdot10^{0}$
15-Mar-46	$1.557\cdot10^{13}$				$8.275\cdot10^{11}$	$8.530\cdot10^{10}$	$7.502\cdot10^{5}$	$1.720\cdot10^{1}$
31-Mar-46	$3.400\cdot10^{13}$				$1.725\cdot10^{12}$	$1.970\cdot10^{11}$	$1.873\cdot10^{6}$	$4.200\cdot10^{1}$
15-Apr-46	$1.103\cdot10^{14}$				$4.995\cdot10^{12}$	$3.127\cdot10^{11}$	$7.148\cdot10^{6}$	$1.330\cdot10^{2}$
30-Apr-46	$4.343\cdot10^{14}$				$4.347\cdot10^{13}$	$3.437\cdot10^{11}$	$3.600\cdot10^{7}$	$5.700\cdot10^{2}$
15-May-46	$2.914\cdot10^{15}$				$1.410\cdot10^{14}$	$6.239\cdot10^{11}$	$3.260\cdot10^{8}$	$4.400\cdot10^{03}$
31-May-46	$6.559\cdot10^{16}$	$2.953\cdot10^{07}$	$3.213\cdot10^{11}$	$4.630\cdot10^{12}$	$1.876\cdot10^{16}$	$6.486\cdot10^{11}$	$1.098\cdot10^{10}$	$1.080\cdot10^{05}$
15-Jun-46	$4.693\cdot10^{18}$	$2.689\cdot10^{09}$	$1.928\cdot10^{12}$	$6.257\cdot10^{12}$	$5.281\cdot10^{17}$	$1.067\cdot10^{12}$	$8.410\cdot10^{11}$	$5.600\cdot10^{06}$
30-Jun-46	$6.277\cdot10^{21}$	$2.448\cdot10^{11}$	$3.534\cdot10^{12}$	$8.456\cdot10^{12}$	$3.950\cdot10^{20}$	$1.170\cdot10^{12}$	$3.086\cdot10^{15}$	$7.500\cdot10^{09}$
15-Jul-46	$7.605\cdot10^{25}$	$1.593\cdot10^{13}$	$1.593\cdot10^{13}$	$1.143\cdot10^{13}$	$4.480\cdot10^{26}$	$1.510\cdot10^{12}$	$1.143\cdot10^{22}$	$1.350\cdot10^{16}$
31-Jul-46	$4.735\cdot10^{25}$	$2.799\cdot10^{15}$	$2.799\cdot10^{15}$	$2.799\cdot10^{15}$	$0.000\cdot10^{00}$	$9.528\cdot10^{13}$	$3.996\cdot10^{29}$	$2.000\cdot10^{21}$

Sources: see text
Notes: 1 Aug 1939=1.000

Table A.2
Primary sources for data on Tax Pengő notes.

Source	Date	Amount in 10^6 TP
Ausch (1958), p.119	on May 29	4,447,810
	on July 15	11,427,723
	on July 23	276,698,900
	on July 31	2,798,667,900
Vágó (1947), p.105	between May 25 and July 9, through the Postal Savings Bank	4,497,810
	between July 9 and July 15, through the National Bank of Hungary	11,427,710
	on July 23, through the National Bank of Hungary	276,698,900
	on July 31, through the National Bank of Hungary	2,798,667,900
Hungarian Institute for Economic Research (1947), p.17.	on July 15	15,779,000
	on July 26	994,500,000
	on August 1	2,580,000,000
Ecker-Racz (1946b), p.5.	on July 15	15,646,410
	on July 23	174,857,240

Table A.3
Data on bank deposits.

	Central Corporation of Banking Companies				Postal Savings Bank					
	Savings accounts		Current accounts		Savings accounts		Current accounts		Total deposits	
Date	P	TP	P	TP	P	TP	P	TP	P	TP
30-Apr-45	$6.631 \cdot 10^{8}$		$2.095 \cdot 10^{9}$		$2.883 \cdot 10^{8}$		$6.984 \cdot 10^{8}$		$3.745 \cdot 10^{9}$	
31-May-45	$6.686 \cdot 10^{8}$		$2.176 \cdot 10^{9}$		$2.907 \cdot 10^{8}$		$7.253 \cdot 10^{8}$		$3.861 \cdot 10^{9}$	
30-Jun-45	$6.355 \cdot 10^{8}$		$2.569 \cdot 10^{9}$		$2.932 \cdot 10^{8}$		$8.250 \cdot 10^{8}$		$4.322 \cdot 10^{9}$	
31-Jul-45	$6.553 \cdot 10^{8}$		$3.274 \cdot 10^{9}$		$3.047 \cdot 10^{8}$		$1.191 \cdot 10^{9}$		$5.425 \cdot 10^{9}$	
31-Aug-45	$6.979 \cdot 10^{8}$		$3.971 \cdot 10^{9}$		$3.076 \cdot 10^{8}$		$1.750 \cdot 10^{9}$		$6.726 \cdot 10^{9}$	
30-Sep-45	$7.263 \cdot 10^{8}$		$5.457 \cdot 10^{9}$		$2.996 \cdot 10^{8}$		$2.278 \cdot 10^{9}$		$8.761 \cdot 10^{9}$	
31-Oct-45	$1.114 \cdot 10^{9}$		$8.517 \cdot 10^{9}$		$3.530 \cdot 10^{8}$		$4.737 \cdot 10^{9}$		$1.472 \cdot 10^{10}$	
30-Nov-45	$1.572 \cdot 10^{9}$		$2.651 \cdot 10^{10}$		$4.911 \cdot 10^{8}$		$8.746 \cdot 10^{9}$		$3.731 \cdot 10^{10}$	
31-Dec-45	$6.178 \cdot 10^{9}$		$5.823 \cdot 10^{10}$		$1.961 \cdot 10^{9}$		$3.213 \cdot 10^{10}$		$9.850 \cdot 10^{10}$	
31-Jan-46	$2.764 \cdot 10^{9}$	$9.673 \cdot 10^{9}$	$9.997 \cdot 10^{10}$	$1.724 \cdot 10^{10}$	$5.560 \cdot 10^{9}$	$0.000 \cdot 10^{0}$	$1.291 \cdot 10^{11}$	$0.000 \cdot 10^{0}$	$2.374 \cdot 10^{11}$	$2.691 \cdot 10^{10}$
28-Feb-46	$5.936 \cdot 10^{9}$	$3.411 \cdot 10^{10}$	$3.502 \cdot 10^{11}$	$4.053 \cdot 10^{10}$	$4.943 \cdot 10^{10}$	$0.000 \cdot 10^{0}$	$4.384 \cdot 10^{11}$	$0.000 \cdot 10^{0}$	$8.440 \cdot 10^{11}$	$7.464 \cdot 10^{10}$
31-Mar-46	$2.014 \cdot 10^{10}$	$1.423 \cdot 10^{11}$	$1.433 \cdot 10^{12}$	$1.165 \cdot 10^{11}$	$5.680 \cdot 10^{11}$	$0.000 \cdot 10^{0}$	$3.942 \cdot 10^{12}$	$0.000 \cdot 10^{0}$	$5.963 \cdot 10^{12}$	$2.587 \cdot 10^{11}$
30-Apr-46	$1.578 \cdot 10^{11}$	$3.280 \cdot 10^{11}$	$8.934 \cdot 10^{12}$	$2.636 \cdot 10^{11}$	$2.456 \cdot 10^{13}$	$0.000 \cdot 10^{0}$	$7.307 \cdot 10^{13}$	$0.000 \cdot 10^{0}$	$1.067 \cdot 10^{14}$	$5.916 \cdot 10^{11}$
31-May-46	$3.890 \cdot 10^{11}$	$5.235 \cdot 10^{11}$	$2.691 \cdot 10^{11}$	$4.579 \cdot 10^{11}$	$1.123 \cdot 10^{14}$	$9.407 \cdot 10^{10}$	$9.620 \cdot 10^{15}$	$0.000 \cdot 10^{0}$	$9.733 \cdot 10^{15}$	$1.076 \cdot 10^{12}$
30-Jun-46	$2.585 \cdot 10^{14}$	$8.092 \cdot 10^{11}$	$1.705 \cdot 10^{20}$	$1.380 \cdot 10^{12}$	$3.860 \cdot 10^{19}$	$2.455 \cdot 10^{11}$	$5.105 \cdot 10^{21}$	$0.000 \cdot 10^{0}$	$5.314 \cdot 10^{21}$	$2.434 \cdot 10^{12}$
31-Jul-46	$0.000 \cdot 10^{0}$	$5.770 \cdot 10^{12}$	$3.707 \cdot 10^{33}$	$1.112 \cdot 10^{14}$	$0.000 \cdot 10^{0}$	$1.022 \cdot 10^{12}$	$0.000 \cdot 10^{0}$	$1.403 \cdot 10^{14}$	$3.707 \cdot 10^{33}$	$2.583 \cdot 10^{14}$

Source: see text

Table A.4
Primary sources for data on deposits at the Central Corporation of Banking Companies.

		Savings accounts			Current accounts			
Source	Date	P	TP	Total in P	P	TP	Total in P	TP index
HIER	31-Jan-46	$2.400\cdot10^{9}$	$8.400\cdot10^{9}$	$1.618\cdot10^{10}$	$1.096\cdot10^{11}$	$1.890\cdot10^{10}$	$1.406\cdot10^{11}$	$1.640\cdot10^{0}$
		14.8%	85.2%		78.0%	22.0%		
NBH	31-Jan-46			$1.863\cdot10^{10}$			$1.282\cdot10^{11}$	$1.640\cdot10^{0}$
HIER	23-Feb-46	$2.600\cdot10^{9}$	$2.730\cdot10^{10}$	$1.497\cdot10^{11}$	$2.643\cdot10^{11}$	$5.590\cdot10^{10}$	$5.656\cdot10^{11}$	$5.390\cdot10^{0}$
		1.7%	98.3%		46.7%	53.3%		
NBH	28-Feb-46			$3.419\cdot10^{11}$			$7.494\cdot10^{11}$	$9.850\cdot10^{0}$
HIER	30-Mar-46	$1.850\cdot10^{10}$	$1.307\cdot10^{11}$	$5.508\cdot10^{12}$	$1.610\cdot10^{12}$	$1.308\cdot10^{11}$	$7.103\cdot10^{12}$	$4.200\cdot10^{1}$
		0.3%	99.7%		22.7%	77.3%		
NBH	31-Mar-46			$5.995\cdot10^{12}$			$6.324\cdot10^{12}$	$4.200\cdot10^{1}$
HIER	27-Apr-46	$1.320\cdot10^{11}$	$3.400\cdot10^{11}$	$1.565\cdot10^{14}$	$7.495\cdot10^{12}$	$2.740\cdot10^{11}$	$1.335\cdot10^{14}$	$4.600\cdot10^{2}$
		0.1%	99.9%		5.6%	94.4%		
NBH	30-Apr-46			$1.871\cdot10^{14}$			$1.592\cdot10^{14}$	$5.700\cdot10^{2}$
HIER	1-Jun-46	$4.920\cdot10^{11}$	$4.470\cdot10^{11}$	$7.152\cdot10^{16}$	$4.910\cdot10^{11}$	$5.640\cdot10^{11}$	$9.024\cdot10^{16}$	$1.600\cdot10^{5}$
		0.0%	100.0%		0.0%	100.0%		
NBH	31-May-46			$5.654\cdot10^{16}$			$4.946\cdot10^{16}$	$1.080\cdot10^{5}$
HIER	28-Jun-46	$8.600\cdot10^{13}$	$6.730\cdot10^{11}$	$2.019\cdot10^{21}$	$6.900\cdot10^{19}$	$1.396\cdot10^{12}$	$4.257\cdot10^{21}$	$3.000\cdot10^{9}$
		0.0%	100.0%		1.6%	98.4%		
NBH	30-Jun-46			$6.069\cdot10^{21}$			$1.052\cdot10^{22}$	$7.500\cdot10^{9}$
HIER	27-Jul-46		$8.360\cdot10^{11}$	$5.852\cdot10^{32}$	$4.430\cdot10^{32}$	$3.798\cdot10^{13}$	$2.703\cdot10^{34}$	$7.000\cdot10^{20}$
					1.6%	98.4%		
NBH	31-Jul-46			$1.154\cdot10^{34}$			$2.262\cdot10^{35}$	$2.000\cdot10^{21}$

Sources: HIER = Hungarian Institute for Economic Research (1947, p. 16)
NBH = National Bank of Hungary (1947, p. 28)

Table A.5
Primary sources for data on deposits at the Postal Savings Bank.

Source	Date	Savings accounts P	Savings accounts TP	Savings accounts Total in P	Current accounts P	Current accounts TP	Current accounts Total in P	TP index
HIER	31-Jan-46	$5.600 \cdot 10^{9}$ 100.7%			$1.291 \cdot 10^{11}$ 100.0%			
NBH	"			$5.560 \cdot 10^{9}$			$1.291 \cdot 10^{11}$	$1.640 \cdot 10^{0}$
HIER	28-Feb-46	$4.940 \cdot 10^{10}$ 99.9%			$4.384 \cdot 10^{11}$ 100.0%			
NBH	"			$4.943 \cdot 10^{10}$			$4.384 \cdot 10^{11}$	$9.850 \cdot 10^{0}$
HIER	31-Mar-46	$5.680 \cdot 10^{11}$ 100.0%			$3.942 \cdot 10^{12}$ 100.0%			
NBH	"			$5.680 \cdot 10^{11}$			$3.942 \cdot 10^{12}$	$4.200 \cdot 10^{1}$
HIER	30-Apr-46	$2.456 \cdot 10^{13}$ 100.0%			$7.307 \cdot 10^{13}$ 100.0%			
NBH	"			$2.456 \cdot 10^{13}$			$7.307 \cdot 10^{13}$	$5.700 \cdot 10^{2}$
HIER	31-May-46	$1.123 \cdot 10^{14}$ 1.1%			$9.620 \cdot 10^{15}$ 100.0%			
NBH	"			$1.027 \cdot 10^{16}$			$9.620 \cdot 10^{15}$	$1.080 \cdot 10^{5}$
HIER	30-Jun-46	$3.860 \cdot 10^{19}$ 2.1%			$5.105 \cdot 10^{21}$ 100.0%			
NBH	"			$1.880 \cdot 10^{21}$			$5.105 \cdot 10^{21}$	$7.500 \cdot 10^{9}$
HIER	31-Jul-46							
NBH	"			$2.043 \cdot 10^{33}$			$2.806 \cdot 10^{35}$	$2.000 \cdot 10^{21}$

Sources: HIER = Hungarian Institute for Economic Research (1947, p. 16)
NBH = National Bank of Hungary (1947, p. 28)

Table A.6
Construction of aggregate measures of the rate of money growth and the rate of return on real balances.

Date	Growth rate of money supply			Monthly aggregate	Rate of return on real balances			Monthly aggregate
	P	TP	Fisher index		P	TP	Fisher index	
30-Apr-45								
15-May-45								
31-May-45				$1.066\cdot10^{0}$				$9.991\cdot10^{-1}$
15-Jun-45								
30-Jun-45				$1.200\cdot10^{0}$				$9.991\cdot10^{-1}$
15-Jul-45	$1.102\cdot10^{0}$		$1.102\cdot10^{0}$		$8.596\cdot10^{-1}$		$8.596\cdot10^{-1}$	
31-Jul-45	$1.039\cdot10^{0}$		$1.039\cdot10^{0}$	$1.145\cdot10^{0}$	$8.843\cdot10^{-1}$		$8.843\cdot10^{-1}$	$7.601\cdot10^{-1}$
15-Aug-45	$1.154\cdot10^{0}$		$1.154\cdot10^{0}$		$7.255\cdot10^{-1}$		$7.255\cdot10^{-1}$	
30-Aug-45	$1.220\cdot10^{0}$		$1.220\cdot10^{0}$	$1.408\cdot10^{0}$	$8.211\cdot10^{-1}$		8.211·10-1	$5.957\cdot10^{-1}$
15-Sep-45	$1.236\cdot10^{0}$		$1.236\cdot10^{0}$		$7.594\cdot10^{-1}$		$7.594\cdot10^{-1}$	
30-Sep-45	$1.310\cdot10^{0}$		$1.310\cdot10^{0}$	$1.620\cdot10^{0}$	$6.098\cdot10^{-1}$		$6.098\cdot10^{-1}$	$4.631\cdot10^{-1}$
15-Oct-45	$1.383\cdot10^{0}$		$1.383\cdot10^{0}$		$3.396\cdot10^{-1}$		$3.396\cdot10^{-1}$	
31-Oct-45	$1.775\cdot10^{0}$		$1.775\cdot10^{0}$	$2.454\cdot10^{0}$	$4.450\cdot10^{-1}$		$4.450\cdot10^{-1}$	$1.511\cdot10^{-1}$
15-Nov-45	$1.819\cdot10^{0}$		$1.819\cdot10^{0}$		$3.721\cdot10^{-1}$		$3.721\cdot10^{-1}$	
30-Nov-45	$1.834\cdot10^{0}$		$1.834\cdot10^{0}$	$3.336\cdot10^{0}$	$4.612\cdot10^{-1}$		$4.612\cdot10^{-1}$	$1.716\cdot10^{-1}$
15-Dec-45	$1.565\cdot10^{0}$		$1.565\cdot10^{0}$		$2.601\cdot10^{-1}$		$2.601\cdot10^{-1}$	
31-Dec-45	$1.394\cdot10^{0}$		$1.394\cdot10^{0}$	$2.182\cdot10^{0}$	$1.074\cdot10^{0}$		$1.074\cdot10^{0}$	$2.794\cdot10^{-1}$
15-Jan-46	$1.239\cdot10^{0}$		$1.239\cdot10^{0}$		$6.930\cdot10^{-1}$	$7.484\cdot10^{-1}$	$6.930\cdot10^{-1}$	
31-Jan-46	$1.709\cdot10^{0}$		$1.709\cdot10^{0}$	$2.117\cdot10^{0}$	$7.685\cdot10^{-1}$	$1.167\cdot10^{0}$	$7.707\cdot10^{-1}$	$5.341\cdot10^{-1}$
15-Feb-46	$1.711\cdot10^{0}$	$2.338\cdot10^{0}$	$1.726\cdot10^{0}$		$5.176\cdot10^{-1}$	$8.553\cdot10^{-1}$	$5.244\cdot10^{-1}$	
28-Feb-46	$1.914\cdot10^{0}$	$1.363\cdot10^{0}$	$1.869\cdot10^{0}$	$3.225\cdot10^{0}$	$3.203\cdot10^{-1}$	$1.164\cdot10^{0}$	$3.475\cdot10^{-1}$	$1.822\cdot10^{-1}$
15-Mar-46	$2.929\cdot10^{0}$	$1.483\cdot10^{0}$	$2.753\cdot10^{0}$		$5.810\cdot10^{-1}$	$1.015\cdot10^{0}$	$6.115\cdot10^{-1}$	
31-Mar-46	$2.179\cdot10^{0}$	$2.309\cdot10^{0}$	$2.196\cdot10^{0}$	$6.046\cdot10^{0}$	$4.005\cdot10^{-1}$	$9.780\cdot10^{-1}$	$4.493\cdot10^{-1}$	$2.747\cdot10^{-1}$
15-Apr-46	$3.227\cdot10^{0}$	$1.587\cdot10^{0}$	$2.719\cdot10^{0}$		$2.620\cdot10^{-1}$	$8.298\cdot10^{-1}$	$3.436\cdot10^{-1}$	
30-Apr-46	$4.144\cdot10^{0}$	$1.099\cdot10^{0}$	$2.767\cdot10^{0}$	$7.525\cdot10^{0}$	$1.986\cdot10^{-1}$	$8.510\cdot10^{-1}$	$3.081\cdot10^{-1}$	$1.059\cdot10^{-1}$
15-May-46	$6.394\cdot10^{0}$	$1.815\cdot10^{0}$	$3.841\cdot10^{0}$		$1.104\cdot10^{-1}$	$8.524\cdot10^{-1}$	$2.475\cdot10^{-1}$	
31-May-46	$2.761\cdot10^{1}$	$1.555\cdot10^{0}$	$6.405\cdot10^{0}$	$2.460\cdot10^{1}$	$2.969\cdot10^{-2}$	$7.288\cdot10^{-1}$	$1.511\cdot10^{-1}$	$3.741\cdot10^{-2}$
15-Jun-46	$6.190\cdot10^{1}$	$3.088\cdot10^{0}$	$1.081\cdot10^{1}$		$1.306\cdot10^{-2}$	$6.770\cdot10^{-1}$	$1.404\cdot10^{-1}$	
30-Jun-46	$1.278\cdot10^{3}$	$1.571\cdot10^{0}$	$2.385\cdot10^{1}$	$2.578\cdot10^{2}$	$2.725\cdot10^{-4}$	$3.650\cdot10^{-1}$	$2.180\cdot10^{-2}$	$3.061\cdot10^{-3}$
15-Jul-46	$7.854\cdot10^{4}$	$3.707\cdot10^{0}$	$2.155\cdot10^{2}$		$2.700\cdot10^{-7}$	$4.860\cdot10^{-1}$	$7.048\cdot10^{-3}$	
31-Jul-46	$9.035\cdot10^{-2}$	$1.660\cdot10^{2}$	$1.658\cdot10^{2}$	$3.572\cdot10^{4}$	$2.860\cdot10^{-8}$	$4.238\cdot10^{-3}$	$4.233\cdot10^{-3}$	$2.983\cdot10^{-5}$

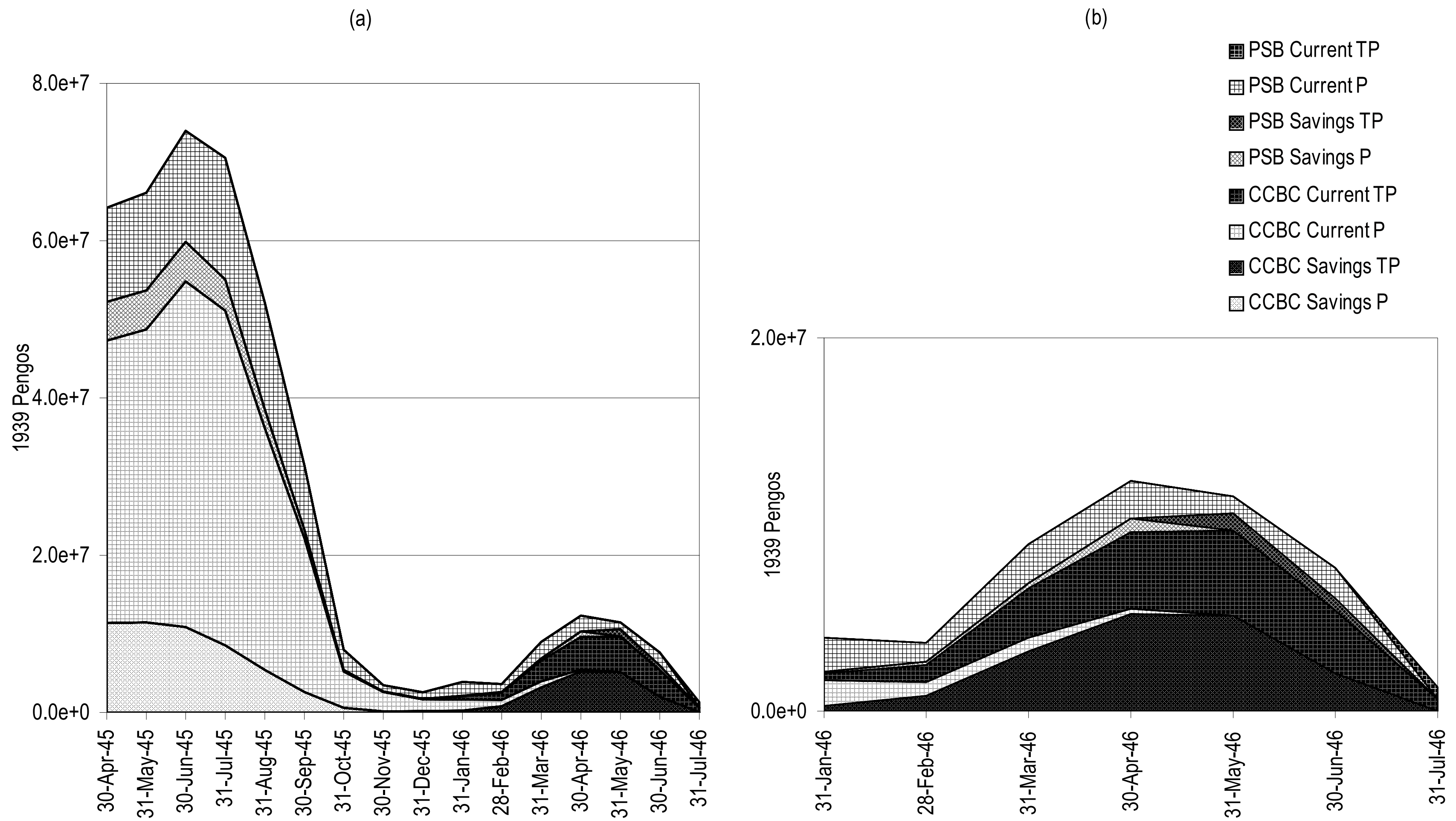


Figure A.1
Real value and composition of bank deposits (monthly).

Appendix B

This appendix contains additional empirical results, which are intended to help judge the robustness of the conclusions in the main text. As the details given in Appendix 1.A.1 reveal, not all the data available from the period of the hyperinflation are very reliable. Therefore, it is useful to see how sensitive the conclusions are to some of the assumptions that I made in order to obtain a consistent set of data. In addition, Cagan (1956) and Sargent and Wallace (1973) based their calculations on money supply data that included deposits, expressed as the total Pengő balance of both indexed and non-indexed deposits. For further comparison, it is interesting to see the behavior of an appropriate M2 aggregate and the rate of return on this aggregate, when these measures are defined analogously to the definitions of the aggregate monetary base and its rate of return.

GENERAL CHARACTERISTICS OF THE HYPERINFLATION

The statistics reported in Table 2 are recalculated in Table B.1 for various definitions of the money supply, and for alternative estimates of the Tax Pengő note supply. The first two columns report results using M2, which includes notes and deposits. Just as we saw earlier, there is a great difference between the figures relating to aggregate M2 versus those relating to only the Pengő denominated component.

Note that since deposit data are only available at the monthly frequency, the aggregate figures calculated using M2 are not exactly comparable to the aggregate figures in Table 2, which were derived from biweekly data. Therefore, column three reports the general statistics about the hyperinflation using the monetary base as the money supply measure, but calculating the index directly on a monthly basis. (When only the Pengő denominated component is considered there is no difference between using monthly versus biweekly raw data, so column four is the same as column two in Table 2.)

Comparing the values in column one to those in column three shows that aggregate M2 grew somewhat faster than aggregate M0 (see rows 5 and 8). The difference between the growth rate of Pengő denominated M2 and Pengő denominated M0, by contrast, is much larger. This implies that the behavior of the deposit/note ratio is less extreme when the aggregate measures are considered than what would appear to be the case when only the Pengő denominated component is taken into account.

The overall rate of depreciation of base money is different from the rate of depreciation of M2 (row 5). The existence of some difference between these two measures is natural, since the composition of M0 between indexed and non-indexed components is not identical to the composition of M2. At the same time, it appears that most of the difference is due to what happened during July 1946 (compare rows 5 and 12). During July, the Tax Pengő Index increased enormously, implying a very large rate of return differential between the Pengő and the Tax Pengő. This means that the calculated average return will be very sensitive to the weights associated with the two components. Moreover, the rate of return on the Pengő and on the Tax Pengő between July 27 and Aug 1 was equal, implying that during the last days of the inflation agents should have been indifferent between denominating their deposits in Pengős versus in Tax Pengős. Thus, the July aggregate rate of return should be regarded as being measured with a potentially much higher error than the figures relating to earlier months.

As a final remark, it is interesting to see the difference that using monthly versus biweekly data makes for the aggregate measures of currency depreciation and money growth. The comparison of column three of Table B.1 and column one of Table 2 reveals that the data frequency does make some difference in the numerical results, as expected. However, a large part of this difference again came from the difference occurring during July, when the changes in agents' portfolios were most dramatic. In any case, the qualitative conclusion that the second Hungarian hyperinflation appears to be similar in severity to the post World War I German hyperinflation is unaffected.

The last three columns compare the results obtained under alternative assumptions regarding the data on Tax Pengő notes. The middle column repeats, for convenience, the results obtained with the Tax Pengő data used in the main text. TP(1) represents lower, while TP(3) represents higher estimated values during May and June 1946. Even though the three different estimates of the Tax Pengő note supply vary widely, the qualitative conclusions are not sensitive to these variations.

THE MONETARY REGIME AND THE MONEY SUPPLY PROCESS

The same alternative definitions of the money supply and estimates of the amount of outstanding Tax Pengő notes as used in Table B.1 can be used to evaluate the sensitivity of the Granger-causality tests to these variations in the data. In addition, since these tests are typically sensitive to structural breaks in the data — which may exist towards the stabilization or may have been inadvertently introduced by using incorrect estimates of some data series — I also repeated the Granger causality tests for various truncated sample periods. Degrees of freedom considerations prevent an explicit search for breaks, but it was possible to drop up to three observation from either the beginning or the end of the data series. The results of estimating equations (4) and (5) are presented in Table B.2 through Table B.5, while the appropriate F-tests are shown in Table B.6.

Using aggregate M2 as the money supply measure, there is strong evidence for unilateral Granger-causality from inflation to money growth. The same evidence is somewhat weaker when only Pengő denominated notes and deposits are considered.

Alternative estimates of the Tax Pengő note supply have mixed effects on the results. When the Vágó (1947) data are used with backwards log-linear extrapolation (TP(1)), the results are essentially unaffected. With Ausch's (1958) data (TP(3)), the pattern of Granger-causality is reversed. However, as I argued in Appendix 1.A, the data originating from Ausch is probably incorrect.

One way to altogether eliminate the influence of the potentially wrong estimates of Tax Pengő notes on the results is to consider a truncated sample. The statistics in Table B.6 show that the pattern of co-movement between inflation and money growth is not altered by the sequential removal of the last few observations. Similarly, the evidence for unilateral Granger-causality from inflation to money growth remains strong when data points from the beginning of the sample are dropped, i.e. when the data affected by potentially erroneous estimates of bank reserves during the April-June 1945 period are excluded.

The only indication that the pattern of co-movement between money growth and inflation is not robust to various methods of obtaining measures of the monetary aggregate appears in the third line of Table B.6. When aggregate base money is considered, and the appropriate measures of the growth rate of the money supply and the rate of currency depreciation are computed using monthly data directly, the clear pattern of unilateral Granger causality from inflation to money growth is not observed. However, as I argued in the text, using monthly data gives only a crude estimate of the rate of return on portfolios when these portfolios are in rapid change over the month. As the results reported in Table B.1 also indicate, the situation where the difference between monthly and biweekly aggregation is greatest is during July 1946. Therefore, it is interesting to remark that if the July observation was dropped (but monthly aggregation was maintained), the original pattern of Granger causality from inflation to money growth would be reestablished. Moreover, exclusion of subsequent observations from the end of the sample would leave the pattern further unaltered. (These results are not shown.)

Overall, the empirical evidence appears to strongly support the robustness of the results to the various alternatives considered here: currency depreciation appears to unilaterally Granger-cause money creation.

Table B.1
General characteristics of the inflation with alternative measures of the money supply.

	Alternative definitions of the money supply				Alternative estimates of TP notes		
	M2, P&TP	M2, P only	M0, P&TP	M0, P only	M0, P&TP(1)	M0, P&TP(2)	M0, P&TP(3)
1. Beginning month	Aug-45	Aug-45	Aug-45	Aug. 1945	Aug. 1945	Aug. 1945	Aug. 1945
2. Ending month	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946
3. Number of months	12	12	12	12	12	12	12
4.a. Real rate of return on money from beginning to end	$8.525 \cdot 10^{-17}$	$1.924 \cdot 10^{-28}$	$4.161 \cdot 10^{-13}$	$1.924 \cdot 10^{-28}$	$5.350 \cdot 10^{-15}$	$1.932 \cdot 10^{-14}$	$7.508 \cdot 10^{-14}$
4.b. Ratio of prices at end to beginning	$1.173 \cdot 10^{16}$	$5.196 \cdot 10^{27}$	$2.404 \cdot 10^{12}$	$5.196 \cdot 10^{27}$	$1.869 \cdot 10^{14}$	$5.175 \cdot 10^{13}$	$1.332 \cdot 10^{13}$
5. Ratio of quantity of money at end to beginning	$6.234 \cdot 10^{14}$	$1.705 \cdot 10^{23}$	$1.332 \cdot 10^{11}$	$2.389 \cdot 10^{15}$	$1.036 \cdot 10^{13}$	$2.868 \cdot 10^{12}$	$7.380 \cdot 10^{11}$
6. Ratio of (4b) to (5)	18.82	$3.048 \cdot 10^{4}$	18.04	$2.175 \cdot 10^{12}$	18.05	18.05	18.05
7.a. Average real rate of return on money (per month)	$4.580 \cdot 10^{-2}$	$4.902 \cdot 10^{-3}$	$9.295 \cdot 10^{-2}$	$4.902 \cdot 10^{-3}$	$6.467 \cdot 10^{-2}$	$7.197 \cdot 10^{-2}$	$8.059 \cdot 10^{-2}$
7.b. Average rate of rise in prices (per month)	2,083%	20,301%	976%	20,301%	1,446%	1,289%	1,141%
8. Average rate of rise in quantity of money (per month)	1,610%	8,529%	745%	1,812%	1,115%	992%	875%
9. Ratio of (7b) to (8)	1.294	2.380	1.309	11.203	1.297	1.300	1.304
10. Month of minimum real return on money	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946	Jul. 1946
11.a. Minimum monthly real return on money (per month)	1.444^{-7}	$7.723 \cdot 10^{-15}$	$1.059 \cdot 10^{-3}$	$7.723 \cdot 10^{-15}$	$2.549 \cdot 10^{-5}$	$2.983 \cdot 10^{-5}$	$2.681 \cdot 10^{-5}$
11.b. Maximum monthly rise in prices (per month)	$6.925 \cdot 10^{8}$%	$1.295 \cdot 10^{16}$%	$9.434 \cdot 10^{4}$%	$1.295 \cdot 10^{16}$%	$1.015 \cdot 10^{7}$%	$3.572 \cdot 10^{6}$%	$2.114 \cdot 10^{6}$%
12. Change in quantity of money in month in row 10. (per month)	$5.807 \cdot 10^{8}$%	$3.198 \cdot 10^{13}$%	$1.005 \cdot 10^{5}$%	$7.096 \cdot 10^{5}$%	$3.923 \cdot 10^{6}$%	$3.352 \cdot 10^{6}$%	$3.730 \cdot 10^{6}$%
13. Ratio of (11b) to (12)	1.193	404.9	0.938	$1.825 \cdot 10^{10}$	2.587	1.066	0.567
14. Month in which real value of money was lowest	Jul. 1946	Jul. 1946	Jun. 1946	Jul. 1946	Jun. 1946	Jun. 1946	Jul. 1946
15. Ratio real value of money in row 14. to value at beginning	0.05415	$3.281 \cdot 10^{-5}$	0.05275	$4.598 \cdot 10^{-13}$	0.02173	0.05275	0.05621

Table B.2
Inflation regressed on money creation: equation **(4)**.
Alternative measures of the money supply.

Money measure	Date	a_0	a_1	a_2	A	a_3	a_4	a_5	a_6	r	D.W.
Alternative definitions of the money supply, aggregation based on monthly data											
M0, P only	Jun-45	0.2620	1.8975	-7151.6814	-0.01	-0.1203	-0.1787	-0.0319	—	-0.9843	1.96
	May-46	(0.2262)	(0.4123)	(4884.7741)		(0.1818)	(0.0657)	(0.0456)			
M2, P only	Jun-45	1.3991	1.4188	-4.4422	0.50	1.1111	-0.5165	-0.3188	—	-0.9999	3.25
	May-46	(0.1560)	(0.1346)	(0.7720)		(0.1607)	(0.0628)	(0.0317)			
M0, P&TP	Jun-45	0.7551	1.4106	-11.1344	0.30	0.4739	-0.4906	-0.1217	—	-0.9999	2.22
	May-46	(0.2374)	(0.2775)	(3.9171)		(0.2247)	(0.1248)	(0.0505)			
M2, P&TP	Jun-45	121.1076	1.5825	-122.4883	0.95	1.5665	-0.5389	-5.4579	—	-0.9999	3.41
	May-46	(7.2210)	(0.1214)	(7.2633)		(0.1341)	(0.0514)	(0.3387)			
Alternative estimates of TP notes											
M0, P&TP(1)	Jun-45	7.0650	1.2632	-8.8834	0.79	1.2946	-0.5839	-0.9564	—	-0.9999	3.17
	May-46	(0.3805)	(0.0849)	(0.5003)		(0.1102)	(0.0526)	(0.0551)			
M0, P&TP(2)	Jun-45	5.2718	1.1864	-7.1554	0.76	1.3074	-0.6484	-0.7597	—	-0.9339	3.04
	May-46	(0.2927)	(0.0794)	(0.4332)		(0.1114)	(0.0569)	(0.0445)			
M0, P&TP(3)	Jun-45	0.5000	1.6815	-866.9451	0.05	0.2054	-0.4804	-0.0469	—	-0.2598	2.56
	May-46	(0.2591)	(0.3113)	(445.8442)		(0.1828)	(0.1088)	(0.0484)			

Note: Standard errors in parenthesis.

Table B.3
Inflation regressed on money creation: equation (4).
Robustness to change in sample period.

Money measure	Date	a_0	a_1	a_2	A	a_3	a_4	a_5	a_6	r	D.W.
Alternative sample periods											
M0, P&TP(2)	Sep-45	110.6854	1.4069	-109.6420	0.96	1.4718	-0.8602	-4.3343	—	-0.9999	3.83
	May-46	(7.9590)	(0.0754)	(8.3648)		(0.0763)	(0.0559)	(0.2434)			
M0, P&TP(2)	Aug-45	4.8847	1.2030	-6.6137	0.75	1.2771	-0.6405	-0.7256	—	-0.9999	3.34
	May-46	(0.3055)	(0.0701)	(0.8217)		(0.0861)	(0.0526)	(0.0327)			
M0, P&TP(2)	Jul-45	3.8740	1.1677	-6.7623	0.70	1.1967	-0.5865	-0.6005	—	-0.9999	3.06
	May-46	(0.1770)	(0.0607)	(0.4553)		(0.0852)	(0.0448)	(0.0264)			
M0, P&TP(2)	Jun-45	5.2718	1.1864	-7.1554	0.76	1.3074	-0.6484	-0.7597	—	-0.9339	3.04
	May-46	(0.2927)	(0.0794)	(0.4332)		(0.1114)	(0.0569)	(0.0445)			
M0, P&TP(2)	Jun-45	6.1936	1.1931	-8.0081	0.78	1.3264	-0.6430	-0.8509	—	-0.9122	3.08
	Apr-46	(0.4643)	(0.0984)	(0.6221)		(0.1256)	(0.0691)	(0.0695)			
M0, P&TP(2)	Jun-45	11.8120	1.3077	-13.4657	0.84	1.3664	-0.556	-1.3515	—	-0.9999	3.11
	Mar-46	(1.5897)	(0.2000)	(1.7410)		(0.1396)	(0.1515)	(0.2132)			
M0, P&TP(2)	Jun-45	2.9137	1.8830	-5.6762	0.60	1.1306	-0.0583	-0.6970	—	-0.8476	3.55
	Feb-46	(0.6962)	(0.9097)	(0.4332)		(0.1539)	(0.476)	(0.2541)			

Note: Standard errors in parenthesis.

Table B.4
Money creation regressed on inflation: equation (5).
Alternative measures of the money supply.

Money measure	Date	b_0	b_1	b_2	B	b_3	b_4	b_5	b_6	r	D.W.
Alternative definitions of the money supply, aggregation based on monthly data											
M2, P&TP	Jun-45	-0.7028	0.2478	36.9854	0.29	0.1565	0.0003	0.1169	—	0.1574	2.11
	May-46	(0.3354)	(0.1416)	(29.9877)		(0.1460)	(0.0558)	(0.0413)			
M2, P only	Jun-45	-0.4644	0.2623	17.3606	0.25	0.1149	0.0327	0.0854	—	-0.0876	2.24
	May-46	(0.2200)	(0.1102)	(13.5019)		(0.1308)	(0.0466)	(0.0285)			
M0, P&TP	Jun-45	-0.3562	0.4820	39.5206	0.12	-0.1139	0.2139	0.0476	—	-0.9234	2.38
	May-46	(0.1136)	(0.1238)	(17.6449)		(0.1325)	(0.0765)	(0.0242)			
M0, P only	Jun-45	-0.4076	0.3140	19.4607	0.22	0.0858	0.0452	0.0726	—	-0.2197	2.35
	May-46	(0.1841)	(0.1038)	(12.7946)		(0.1297)	(0.0446)	(0.0248)			
Alternative estimates of TP notes											
M0, P&TP(1)	Jun-45	-0.3093	0.5532	198.3985	-0.05	-0.2532	0.2047	0.0683	—	-0.8328	2.37
	May-46	(0.1181)	(0.1506)	(132.7909)		(0.1675)	(0.0732)	(0.0213)			
M0, P&TP(2)	Jun-45	-0.5306	0.3052	17.2617	0.26	0.1135	0.0714	0.0794	—	-0.1717	2.38
	May-46	(0.2211)	(0.1262)	(10.6903)		(0.1574)	(0.0760)	(0.0336)			
M0, P&TP(3)	Jun-45	-0.6791	0.3428	4.6898	0.49	0.2069	0.1410	0.0348	—	-0.2830	2.56
	May-46	(0.2754)	(0.1155)	(2.2228)		(0.1634)	(0.0682)	(0.0417)			

Note: Standard errors in parenthesis.

Table B.5
Money creation regressed on inflation: equation (5).
Robustness to change in sample period.

Money measure	Date	b_0	b_1	b_2	B	b_3	b_4	b_5	b_6	r	D.W.
Alternative sample periods											
M0, P&TP(2)	Sep-45	-3.0594	0.7042	340.4749	0.37	0.2949	-0.2189	0.2622	—	-0.4637	2.98
	May-46	(1.3580)	(0.2484)	(192.8524)		(0.2120)	(0.1730)	(0.1063)			
M0, P&TP(2)	Aug-45	-1.8892	0.4735	99.8194	0.40	0.3151	-0.1220	0.1702	—	-0.0532	2.62
	May-46	(0.9986)	(0.1875)	(70.1112)		(0.1937)	(0.1707)	(0.0817)			
M0, P&TP(2)	Jul-45	-0.4738	0.5546	-702.1544	-0.09	-0.1793	0.1700	0.0845	—	-0.8361	2.14
	May-46	(0.1352)	(0.1448)	(468.6422		(0.1708)	(0.0697)	(0.0202)			
M0, P&TP(2)	Jun-45	-0.5306	0.3052	17.2617	0.26	0.1135	0.0714	0.0794	—	-0.1717	2.38
	May-46	(0.2211)	(0.1262)	(10.6903)		(0.1574)	(0.0760)	(0.0336)			
M0, P&TP(2)	Jun-45	-0.3554	0.5186	93.1859	0.08	-0.1757	0.2462	0.0488	—	-0.8309	2.44
	Apr-46	(0.1326)	(0.1508)	(51.5326)		(0.1807)	(0.0972)	(0.0294)			
M0, P&TP(2)	Jun-45	-10.8500	0.6919	63.8779	0.78	0.3825	0.0867	0.4834	—	0.7199	2.96
	Mar-46	(4.8367)	(0.2199)	(28.0494)		(0.1546)	(0.1260)	(0.3212)			
M0, P&TP(2)	Jun-45	-0.1091	0.4176	61.0936	-0.06	-0.0442	-0.0650	0.0729	—	-0.7479	3.53
	Feb-46	(0.0736)	(0.0791)	(53.2776)		(0.0863)	(0.0806)	(0.0131)			

Note: Standard errors in parenthesis.

Table B.6
F-statistics for testing joint significance of future values of the independent variable.

Money supply measure	Date		(4) π regressed on μ	(5) μ regressed on π	Degrees of freedom	Critical values of F	
						p=0.05	p=0.01
Alternative measures of the money supply, aggregation based on monthly data							
M2, P&TP	Jun-45	May-46	68.28	2.58	5	5.79	13.27
M2, P only	Jun-45	May-46	36.12	8.94	5	5.79	13.27
M0, P&TP	Jun-45	May-46	9.47	13.38	5	5.79	13.27
M0, P only	Jun-45	May-46	6.62	11.49	5	5.79	13.27
Alternative estimates of TP notes							
M0, P&TP(1)	Jun-45	May-46	69.81	9.35	5	5.79	13.27
M0, P&TP(2)	Jun-45	May-46	71.72	5.60	5	5.79	13.27
M0, P&TP(3)	Jun-45	May-46	9.81	20.14	5	5.79	13.27
Alternative sample periods							
M0, P&TP	Sep-45	May-46	194.05	1.01	2	19.00	99.00
M0, P&TP	Aug-45	May-46	110.45	2.09	3	9.55	30.82
M0, P&TP	Jul-45	May-46	99.35	7.50	4	6.94	18.00
M0, P&TP	Jun-45	May-46	71.72	5.60	5	5.79	13.27
M0, P&TP	Jun-45	Apr-46	56.47	5.29	4	6.94	18.00
M0, P&TP	Jun-45	Mar-46	51.10	3.06	3	9.55	30.82
M0, P&TP	Jun-45	Feb-46	34.12	1.56	2	19.00	99.00