Long-run money demand in Switzerland

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This paper studies long-run demand functions for Swiss M1 and M3, using annual data spanning the period 1907-2016. While the demand functions display plausible price and income elasticities, tests for structural breaks at unknown points in time detect instability in 1929 for real M1 and 1943 for real M3. This instability appears to arise from the way in which the opportunity cost is modelled. While using a single interest rate may be appropriate for M1, for M3 it would likely be helpful to take into consideration both the own return and the return on non-monetary assets.

JEL codes: E4, E5, N1
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1 Introduction

The demand for money receives little, if any, attention in modern macroeconomic textbooks and in current discussions about monetary policy. Yet it has long been seen as a central part of monetary theory and, historically, it has also been of great practical importance to central banks.[2] Indeed, a stable money demand function is commonly viewed as a prerequisite for the use of monetary targeting (GOLDFELD, 1987; GOLDFELD and SICHEL, 1990). It is therefore not surprising that the demand for money has been subjected to extensive empirical scrutiny, particularly in economies in which the central bank has targeted money growth.[3]

That includes Switzerland, where the Swiss National Bank (SNB) introduced monetary targeting in late 1974 and continued to place emphasis on the monetary aggregates until it introduced its current policy framework in 2000. Not surprisingly, BALTENSPERGER and KUGLER (2017) contains an extended discussion of the demand for money in Switzerland. The authors also present new empirical evidence on the demand for M1, using annual data for the period

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2 One indication of how unimportant money demand has become as a topic in macroeconomics is the fact that some of the most frequently cited articles on money demand were all published by 1990 (e.g., JUDD and SCADDING, 1982; GOLDFELD, 1973; GOLDFELD and SICHEL, 1990). It should be noted that the ECB continued to attach a prominent role to money in the setting of monetary policy until at least the mid-2000s.

3 See RICH (2003) and BALTENSPERGER (2007) for a review and analysis of monetary targeting in Switzerland.

1851-2010, suggesting that there is a long-run relationship between M1, prices, real GDP and a single interest rate.

As they note, over the 160-year period they study, several different monetary regimes were in force in Switzerland, ranging from a metallic standard via the Bretton Woods system of fixed exchange rates to a fiat paper standard. While the long-run money demand function is likely to remain constant across regimes, the dynamic adjustment of the variables to the cointegrating relationship is quite likely to depend on the monetary regime in operation. For instance, under fixed exchange rates and an open capital account (when the level of the prices and the interest rates are given from abroad), the literature on the monetary approach to the balance of payments suggests that the money stock will adjust over time to ensure that the variables share a common trend.[4] Under floating exchange rates, by contrast, movements in prices, the exchange rate and interest rates, rather than in money supply, may move to ensure equilibrium.

Since the dynamic adjustment of the variables in the cointegrating system may consequently have varied over time, Baltensperger and Kugler (2017) first use single equation methods to estimate the cointegrating vector, before studying the stability of the relationship and the dynamic adjustment patterns.

The main contribution of this article is to provide new cointegration estimates on the long-run demand for M1 and M3 in the period 1907-2015. It is closely related to the analysis in Baltensperger and Kugler (2017).[5]

To preview the results, there are five main findings in the paper. First, the price elasticities of the demand for M1 and M3 are unity, that is, the demand for money is a demand for real money balances. Second, the income elasticities of money demand are around 1.2 for M1 and around 1.4 or M3. Third, the demand for M1 depends negatively on the interest rate paid on savings deposits. Since savings deposits are part of M3 but not M1, that interest rate captures the opportunity cost of holding M1 and the own return on M3. Fourth, and perhaps surprisingly, the demand for M3 also depends negatively on this interest rate. This suggests that the opportunity cost of holding M3 – the spread between the returns on the non- monetary assets that are substitutes for M3 and the interest rate on savings deposits – must be positively correlated with the interest rate on savings deposits. Unfortunately, despite considerable experimentation, it has not been possible to construct a direct measure of this opportunity cost. Fifth, tests for structural breaks at unknown points in time detect instability in the 1929-1943 period.

4 For the monetary approach to the balance of payments, see Frenkel and Johnson (1976).

5 There are few papers that study the long-run demand for money in Switzerland. An exception is Gerlach-Kristen (2001), which provides an analysis on Swiss money demand using data spanning the period 1936-1995.

This instability appears to arise from the way in which the opportunity cost is modelled. The finding that the demand for money in Switzerland has been stable for at least the last 75 years is striking.

The rest of the paper is structured as follows. Section 2 contains a discussion of money demand, Section 3 turns to the data, Section 4 discusses the estimation and Section 5 concludes.

2 Money demand

A great deal of attention has been paid over time by academic and central bank economists to the question of whether long-run money demand functions are stable. However, the notions of "long run" and "stability" have both evolved over time.

Historically, money demand functions were specified and estimated using the log-levels of money, the price level, and real GDP as a measure of the transactions demand for money. The opportunity cost of holding money, which was typically captured by an interest rate, was included either in level or log-level form (Goldfeld, 1990). In the post 1980-literature, "long run" has generally been interpreted as implying a cointegrating relationship between the selected monetary aggregate, prices, real GDP and a measure of the opportunity cost of holding money.

As the literature on non-stationarity and error correction developed over time, researchers continued to estimate money demand function in levels, but with improved econometric methods. Moreover, in the case of single equation models, the estimator evolved from ordinary least squares (OLS) to fully modified OLS (FM-OLS) and dynamic OLS (DOLS).[6] Moreover, testing for cointegration become a central element when studying the long-run properties of money demand. Baltensperger and Kugler (2017) follow this approach.

The notion of stability has also evolved over time. Friedman (1956) spoke of money demand being a stable function of a limited number of variables. The focus of the money demand literature that followed in this tradition has not been on narrow econometric stability, in the sense of rejecting tests of the hypothesis of parameter constancy.[7] Rather, the idea has been that calibrated money demand functions would fit scatter plots of the data, including data from periods not

6 FM-OLS was proposed by Phillips and Hansen (1990) and DOLS by Stock and Watson (1993).
7 For an example of this research agenda, see Hendry and Ericsson (1991).

considered in the calibration exercise.[8] This approach may be due to Lucas (1988), who presents a scatter plot of the logarithm of velocity against a nominal interest rate for the same period that Metzler (1963) investigates in his seminal study – 1900 to 1957 – which suggests a clear negative relationship between the two variables. Lucas goes on to expand the sample until 1985 and shows that the new data would appear to fit any relationship estimated on Meltzer's original data.

The introduction of monetary targeting in the 1970s provided a powerful stimulant to research on money demand since it raised the issue of what the monetary growth target should be. Consider a standard money demand function of the form:

$$m_t - p_t = \alpha + \beta y_t + \delta r_t + \varepsilon_t \tag{1}$$

where m_t denotes the logarithm of the monetary aggregate considered; p_t the logarithm of some measure of the price level; y_t the logarithm of real GDP as a measure of the transactions demand for money; r_t the opportunity cost of holding the monetary aggregate in question (which we assume here is captured by a single interest rate, but which could be a vector of interest rates potentially also including the expected rate of inflation); and ε_t a money demand shock. Since money, prices and income (and perhaps the opportunity cost of holding money) are non-stationary, the modern literature views the stationarity of the error term in equation (1), coupled with constancy of the parameters in that equation, as indicating the presence of a stable long-run money demand function.

In that case, proponents of monetary targeting would proceed by solving the money demand for the rate of inflation, that is, the change in the log of the price level:

$$\Delta p_t = \Delta m_t - \beta \Delta y_t - \delta \Delta r_t - \Delta \varepsilon_t \tag{2}$$

Equation (2) states that the rate of inflation equals the rate of money growth, adjusted for changes in money demand coming from real income growth and shifts in velocity coming from changes in the opportunity cost of holding money and demand shocks. If the parameters in this equation are stable, a money growth target can then be computed using, for instance, a measure of desired or unavoidable inflation, and forecasts of output growth and changes in velocity.[9] By seeking to achieve the targeted money growth rate, the central bank could attempt to control inflation.

8 The paper in this issue by Nicolini (2017) is a case in point.
9 The SNB's approach is discussed in detail in Rich (2003).

With the benefit of hindsight, this approach warrants three comments.

First, there has been a tendency among policy-makers to confuse the existence of a stable long-run money demand function with the idea that money growth causes inflation. Formally, cointegration among money, prices and income implies that at least one of these variables moves over time to ensure a common trend. RICH (2003) states that it was assumed at the SNB that inflation was the equilibrating factor. However, BALTENSPERGER and KUGLER (2017) note that above-average money growth could be followed by above-average income growth or below-average money growth.[10] There is therefore no presumption that a stable money demand function implies that excessive money growth leads to inflation; whether that is the case depends on the monetary regime and is thus an empirical question.

Second, the notion of econometric stability is slippery. It is more difficult to reject the hypothesis of parameter constancy in equations that fit the data poorly, since a poor fit – arising from a large variance of the residuals – translates into wide standard errors for the estimated parameters. A failure to reject the hypothesis of parameter constancy may thus simply reflect a lack of power.

Third, instability in money demand relationships is often viewed as evidence that money is mismeasured, leading to a search for a redefinition of money to achieve stability. While what serves as money is surely evolving over time in response to changes in the financial system, the frequent need for a redefinition of the monetary aggregates suggests that policy-makers should expect the pattern of recurrent breaks to continue in the future. While it may be possible to restore ex post a stable money demand function after such breaks, they undermine the real-time information content of money, and therefore the likelihood that a monetary-targeting strategy will be successful.

3 The data

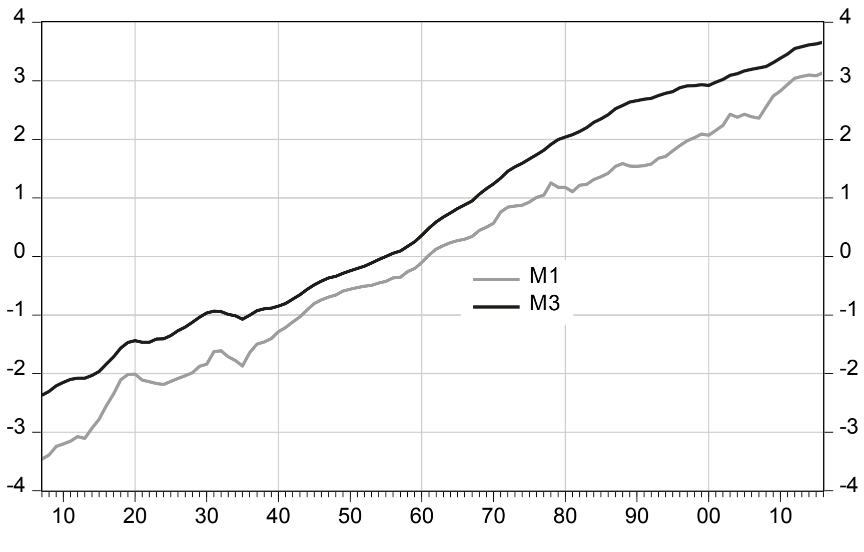
Next, I turn to the empirical work. While it follows that of BALTENSPERGER and KUGLER (2017) in spirit, there are differences. First, because of a lack of price data, they estimate the demand for nominal M1 using nominal GDP to capture the transactions demand and, consequently, implicitly assume that the price and income elasticities of money demand are equal. Since real and nominal GDP data are now available from 1851 onward, I estimate the money demand function in real terms.

10 It is also possible that the adjustment occurs trough changes in interest rates.

Second, I consider a slightly different sample period by dropping the period 1851-1906 and by extending the sample to 2016. The reason for doing so is that BALTENSPERGER and KUGLER (2017) find a very high nominal income elasticity of money demand before 1913. However, as GERLACH and KUGLER (2017) demonstrate, that finding is due to the rapid monetization of the Swiss economy (as measured by the number of bank offices in operation) in this period. If this is not controlled for in estimation, estimates of the income elasticity of money demand are biased upward. To avoid having to control for the rapid growth of the Swiss banking system in the period before the establishment of the SNB, I focus below on the period 1907-2016. For this period, there are data on both M1 and M3, so I extend BALTENSPERGER and KUGLER's analysis by also considering M3.

With those preliminaries in mind, I turn to the data, which are constructed by splicing time series from the *Historical Statistics on Switzerland Online* and the SNB's website, in particular the section for "Historical Time Series".[11] Figure 1 shows the logarithms of M1 and M3.[12] The growth rates of the two monetary aggregates, as evidenced by the slope of their plots, are surprisingly stable over time. Switzerland was thus a low money-growth economy throughout the period under consideration. However, there were marked swings in the stocks of both M1 and M3 in the period between the outbreaks of World Wars I and II.

Figure 1 M1 and M3 (in logarithms)



11 See http://www.fsw.uzh.ch/histstat/main.php.
12 To facilitate comparison, all time series except the interest rate have been demeaned.

Figure 2 shows the logarithms of the CPI and real GDP. The price level shows more variation. It reached a peak in 1920 but then fell on average a little over 3% per annum until 1934, when it reached a trough. While prices fell during five years between 1934 and 2010, since 2010 the price level has fallen in five of six years. Real GDP displays even greater fluctuations. Thus, real income growth stalled during World War I and experienced a massive contraction in 1921. Growth then returned but was halted in 1930-1945, when real GDP remained broadly flat. Growth returned in 1946 and continued at a high rate until 1974, when it turned sharply negative after the first oil shock. Although the growth rate turned positive again soon after, GDP has never grown as fast since as in the pre-1974 period. It is notable that also these data series show marked fluctuations in the 1915-1940 period, suggesting that it may be difficult to fit stable money demand functions before then.

Figure 2 Prices and real GDP (in logarithms)

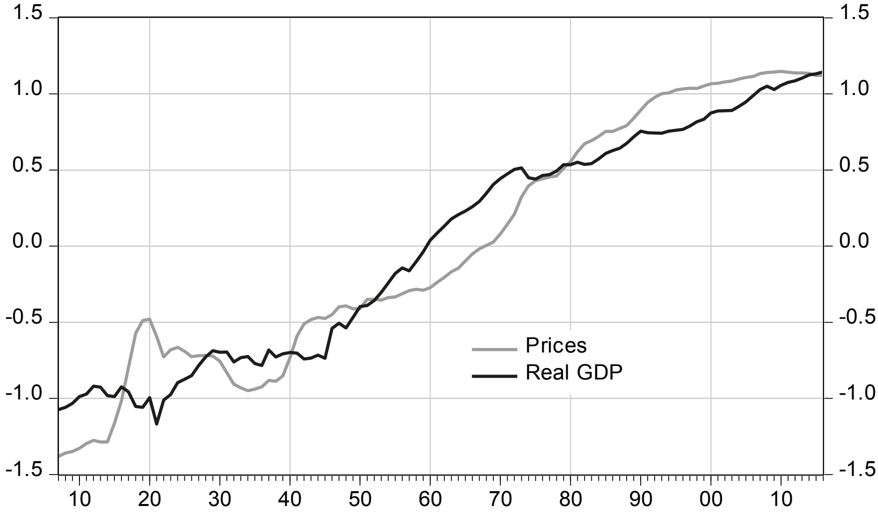


Figure 3 contains plots of the logarithms of real M1 and real M3. While real GDP grew from about -1 in 1907 to 1 in 2016, real M1 and M3 grew from about -2 in 1907 to about 2 in 2016. This suggests that the income elasticity of money demand is likely to be above unity.

Figure 3 Real M1 and M3 (in logarithms)

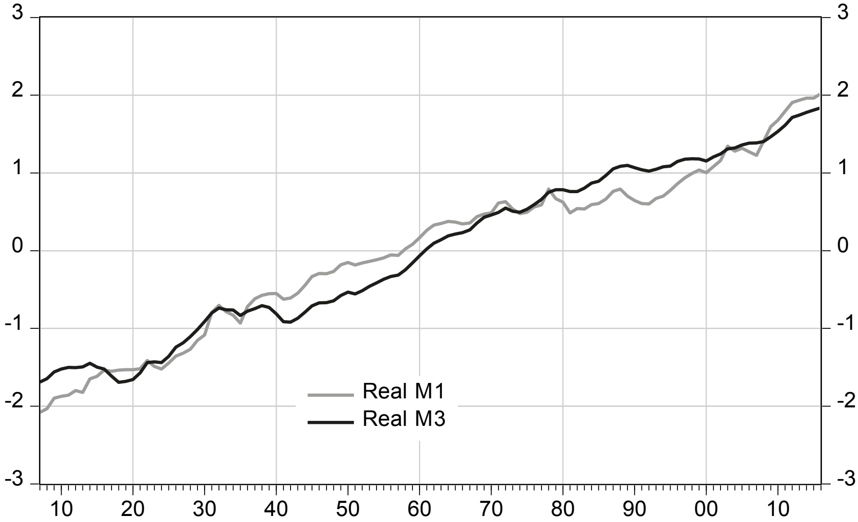


Figure 4 shows the interest rate on savings deposits, which BALTENSPERGER and KUGLER (2017) use to capture the opportunity cost of holding M1, as I do too. The flexibility of that interest rate has increased drastically over the 110-year period that is studied here, suggesting that it may be a source of instability in the demand functions for M1 and M3 estimated below. Thus, the interest rate showed little variation between 1907 and 1930, ranging from 3.80% to 4.55%, despite pronounced swings in money, prices and output. It then fell sharply in the early 1930s as the Great Depression took hold and reached 3% in 1933. It continued to decline gradually and reached 2.5% in 1941, remaining at that level until the late 1950s. It rose consistently in the 1960s and peaked in 1974, before falling sharply in 1979. It then showed large swings before reaching a new peak in 1992, after which it gradually fell to almost zero at the end of the sample.

As noted above, in the literature on money demand it is common to plot the velocity of money against the opportunity cost. This is a powerful way to explore the hypothesis that money demand can be thought of as involving a stable function between merely two variables.

Figure 4 Interest rate on savings deposits

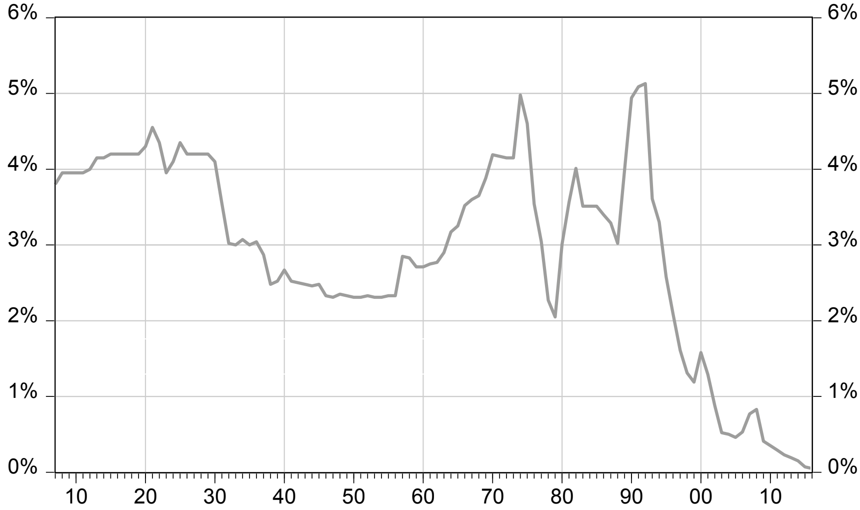


Figure 5 shows a scatter plot of the logarithm of M1 velocity and the interest rate on savings deposits. The figure shows a set of data points in the upper-left corner. Closer inspection reveals these data points span the period 1907-1930. It thus seems likely that the formal econometric analysis below will indicate a break around the 1930s.[13] Looking at the data points for 1931-2016, it appears likely that a stable relationship will be found.

Figure 6 shows the scatter gram of the logarithm of M3 velocity and the interest rate on savings deposits. Here, three groups of data points are apparent: in the upper-left corner, a horizontal cluster of data points for 1907-1930; in the middle, a vertical cluster of data points for the period 1931-1973; and on the right, a downward-sloping cluster of data points for the period 1974-2016.

A plausible explanation for the lack of a clear inverse relationship between velocity and the opportunity cost is that the latter is poorly measured. Thus, the lack of flexibility of the interest rate on savings deposits renders this a poor measure of the opportunity cost of M1 prior to the 1930s. Furthermore, and as I discuss below, the interest rate on savings deposits captures the own return on part of M3 and thus not its opportunity cost. Unfortunately, efforts to construct a better measure of the opportunity cost of M3 using various measures of bond yields were all unsuccessful.

13 Of course, there is no reason why the income elasticity of money demand must be exactly unity.

Figure 5 Interest rates and M1 velocity (in logarithms)

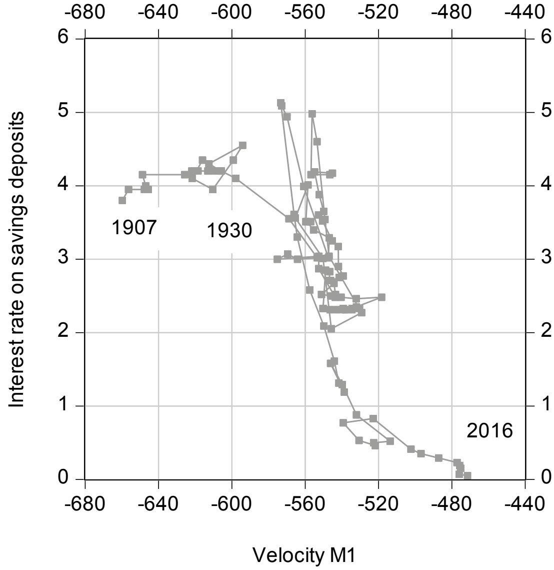
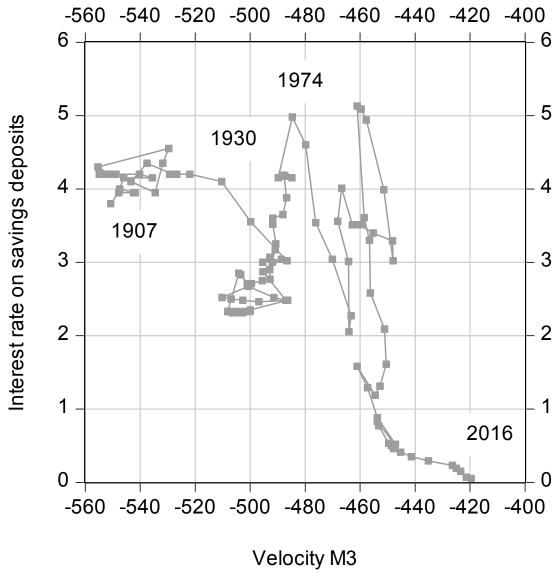


Figure 6 Interest rates and M3 velocity (in logarithms)



4 Estimates

Next, I turn to the estimates, which are obtained using DOLS, with the number of leads and lags selected using the Schwarz Information Criterion, subject to a maximum of two. As regressors, I use the price level, real GDP and the interest rate paid on saving deposits. It should be noted that savings deposits are included in M3, but not in M2 or M1.[14] It is therefore unclear how changes in the interest rate on savings deposits impact the demand for M3. It may increase demand for M3 as it captures the return to one of the components of M3; it may also reduce demand for M3, if changes in the interest rate on savings deposits reflect even greater movements in the yield on non-monetary assets. The interest rate elasticity of M3 demand is thus an empirical question, which I explore below.

Panel A in Table 1 provides estimates for M1. In the first line, I regress nominal M1 on the price level, real GDP and the interest rate on savings deposits. Economic theory and empirical evidence for other economies suggest that the price elasticity of money demand is unity, and the income elasticity of money demand is about unity for M1 and perhaps a little larger for M3. The price elasticity of money demand is 0.98, the income elasticity of money demand is 1.24, and the interest rate elasticity is negative. All three parameters are highly significant. Overall, these estimates are much as one would have expected.

Before looking at the other estimates, I turn to the issue of cointegration (and will delay the discussion of parameter instability and the results from the Bai-Perron test in the last column to later). I first perform an Engle-Granger test in which the hypothesis tested is that there is no cointegration. The p-value is 0.37, indicating that the hypothesis is not rejected. I go on to perform a Hansen test, in which the hypothesis tested is the reverse, that is, that there is cointegration. Interestingly, I cannot reject that hypothesis either ($p > 0.20$). As we will see below, this is the case for all the regressions that I estimate. These conflicting findings reflect the limited power of these tests, and I proceed under the assumption that the series are indeed cointegrated.

Next, I re-estimate the equation under the assumption that the price elasticity is unity. The results are similar to those discussed above and I therefore do not review them in detail. It is noteworthy, however, that the standard error on the income elasticity of money demand falls from 0.22 to 0.07. The high standard error in the previous regression reflects the fact that the data are not clear on the extent to which the increase in M1 should be attributed to the price level versus the level of income, both of which rise gradually over time. Once I have assumed

14 This is clear from Table 2.3 of the SNB's historical database with monetary aggregates.

a value for the price elasticity of money demand, it becomes much clearer how much of the increase in real M1 over time is attributed to real income.

I proceed by regressing M3 minus M1 on the price level, real income and the interest rate on savings deposits. The results are shown in Panel B. The fact that the parameters on the price level and real income are both insignificant suggests that the price and income elasticities of demand are the same for these monetary aggregates. Interestingly, the parameter on the interest rate on savings deposits is now positive and highly significant.

Since, as noted earlier, savings deposits are a part of M3 but not of M1, this is not surprising. Nevertheless, it does raise the question of how the demand for M3 depends on the savings deposit rate, which I consider next.

The first row in Panel C shows the equation for the demand for nominal M3. The price elasticity is estimated to be 1.07, but is insignificantly different from unity. The income elasticity is estimated to be 1.31 and statistically significantly different from unity. Interestingly, the parameter on the interest rate on savings deposits is negative and significant, but is much smaller than in the case of the regressions for M1. This suggests that a generalized rise in interest rates does lead households to shift funds from M1 to M3, and to non-monetary assets as well.

I end the discussion by looking at the last column of Table 1, which contains the results for Bai-Perron tests for structural breaks at unknown points in time. The tests are computed using 15% trimming and a 5% significance level. The years indicated in the first line show breaks under the assumption that the error distribution is the same for all sub-periods, and the second line, in italics, shows the breaks under the assumption that the error distribution may differ between periods.

Interestingly, there are fewer breaks if I impose the restriction that the price elasticity of money demand is unity, which seems appropriate. For real M1, I find no break if we constrain the variance of the errors to be the same across sub-periods and a break in 1929 if we let the error distribution vary. For real M3, I find a break if the error distribution is kept constant across sub-periods, but one in 1943 if it is permitted to change.[15]

15 The year shows the start of the second sub-period.

Table 1: DOLS estimates of Long-run money demand function, 1907-2015

Dependent variable	**Price level**	**Real GDP**	**Interest rate on savings deposits**	**R^2**	**Engle-Granger, p- val.**	**Hansen, p- val.**	**Bai-Perron Same/ *different dist.***
			Panel A				
Nominal M1	0.98*** (0.21)	1.24*** (0.22)	-17.13*** (4.17)	0.99	0.37	> 0.2	1936 *1936, 1956*
Real M1		1.22*** (0.07)	-17.22*** (4.05)	0.96	0.22	> 0.2	1929 *None*
			Panel B				
Nominal M3 – nominal M1	0.07 (0.17)	0.09 (0.19)	12.28*** (3.53)	0.36	0.60	> 0.2	1979 *1979, 1995*
			Panel C				
Nominal M3	1.07*** (0.11)	1.31*** (0.11)	-4.45** (2.11)	1.00	0.52	> 0.2	1936 *1936, 1959*
Real M3		1.38*** (0.04)	-5.62** (2.58)	0.99	0.30	> 0.2	1943 *None*

Notes: ***/**/* denotes significance at the 1%/5%/10% level. Standard errors in parenthesis. The null hypothesis for the Engle-Granger test is that the series are not cointegrated; the null hypothesis for the Hansen test is that the series are cointegrated. The Bai-Perron tests for multiple breakpoints at unknown points in time are computed using 15% trimming, a 5% significance level. Years indicated in the first line shows the breaks under the assumption that the error distribution is the same for all subperiods, and the second line, in italics, shows the breaks under the assumption that the error distribution may differ between periods. The equations are all estimated with DOLS, using the Schwartz information criterion to select leads and lags, subject to a maximum of two.

It seems likely that this instability arises from the measure of opportunity cost which is used here. First, although using a single interest rate on savings deposits may capture opportunity cost adequately in the case of M1, that interest rate captures the own return on part of M3 and is therefore unsatisfactory. Indeed, it would seem desirable to incorporate the return on non-monetary assets in the demand for M3 functions. As mentioned above, attempts to do so using bond yields were unsuccessful.

Second, the interest rate used here varies little over the period 1907 to 1930. In contrast, money, prices and output exhibit marked swings during this time. This also suggests that the interest rate may be a poor measure of the opportunity cost of M1.

5 Conclusions

The main contribution of this paper, which is closely related to the analysis in Baltensperger and Kugler (2017), is to provide new estimates on the long-run cointegration properties of the demand for M1 and M3 in Switzerland in the period 1907-2015.

The results show plausible price and income elasticities of demand. In particular, estimates of price elasticities are statistically insignificantly different from unity, as theory suggests, indicating that the demand for money is a demand for real money balances. This enables me to estimate the equation under the assumption that the price elasticity is unity. This restriction results in an estimate of the income elasticity which is about 1.2 in the case of M1, and 1.4 in the case of M3. This suggests that assuming a value for the price elasticity of money demand clarifies how much of the increase in the real money over time is attributable to real income.

The sample period used here is characterized by several different monetary regimes in Switzerland, including a metallic standard, the Bretton Woods system of fixed exchange rates, and the fiat paper standard of today. Perhaps surprisingly, however, when I test for structural breaks at unknown points in time, my estimated money demand functions, the results generally indicate merely no or one shift in the estimated relationship if the price elasticity of money demand is constrained to be unity. In the case of M1, the break is in 1929; in the case of M3 it is in 1943. This is consistent with scatter plots of velocity of M1 and M3 against the interest rate on savings deposits, which indicate that the observations for the period 1907-1930 lie off the main cluster of data points.

It seems likely that this instability arises from the use of the interest rate on savings deposits, which are included in M3 but not in M1, to capture the opportunity cost of holding money. First, this interest rate shows little variation between 1907 and 1930 despite pronounced swings in money, prices and output. This suggests that it is a poor measure of the opportunity cost of M1.

Second, while this interest rate captures the own return on M3 and is an appropriate measure of the opportunity cost of holding M1, for M3 it would be desirable to make a distinction between the own return and the return on non-monetary assets that are the main alternatives to holding M3. The use of a single interest rate that captures the return on M3 seems too simple a specification. Unfortunately, despite considerable experimentation, it has not been possible to construct such a measure of the opportunity cost of M3.

Overall, I conclude that the long-run money demand functions estimated here do display some instability, and that further work on the specification of the opportunity cost of holding Swiss M1 and M3 in the period studied here is warranted.

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