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### Conference Paper The use of large denomination banknotes in Switzerland

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# The use of large denomination banknotes in Switzerland<sup>\*</sup>

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#### Abstract

We study the demand for Swiss banknotes over the period from 1956 to 2015 and present stylized facts on different banknote denominations since the inception of the Swiss National Bank (SNB) in 1907. Employing the so-called seasonal method, we focus on the demand for banknotes used as a store of value ("hoarding"), which can be expected to be particularly relevant for Switzerland against the backdrop of its status as a safe-haven country, its currently and historically low level of interest rates, and a banknote denomination with the largest value among advanced countries. Due to the pronounced seasonal pattern of CHF 1000 banknotes, which might not be related to transactions, we cannot rely on seasonal ranges including the December peak. Instead, we employ other peak dates as well as a method to correct for the excess seasonality, using institutional features of the tax system. The latter approach is not sufficient to eliminate the excess seasonality and thus does not lead to plausible estimates for the hoarding share of CHF 1000 banknotes. Employing other peak dates, however, indicates that since the turn of the millennium the share of CHF 1000 banknotes that is hoarded increased steadily from around 30% in the mid-1990s to over 70% in recent years.

Keywords: currency in circulation, banknotes, hoarding

**JEL Classification:** E41, E52, E58

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#### 1. Introduction

During the recent financial crisis, many countries experienced a noticeable increase in banknote demand. In particular, after the bankruptcy of Lehman Brothers in September 2008, which triggered concerns about the solidity of the banking system, large denomination banknotes were in high demand to protect financial wealth against bank failures.<sup>1</sup> This is just one example of many, where banknotes are not only demanded as a medium of exchange but - being money - perform their function as a store of value, next to being the unit of account. Central banks have an interest in knowing the share of currency in circulation used for transaction and for store-of-value purposes, respectively. This is relevant both for managing the supply of those banknotes, but also for monetary policy. An estimate of the share of currency in circulation not used for transaction purposes, for instance, helps when interpreting monetary aggregates and thereby when assessing the stance of monetary policy.<sup>2</sup> Moreover, the demand elasticity for cash being used as a store of value might affect the implementation of monetary policy in a low interest rate environment. Additionally, to perform its day-to-day task of supplying and handling the economy's cash in circulation, the central bank needs to have an idea of important features of the demand side. For example, a larger share of cash used as a store of value might imply a lower variability in the demand for cash. Finally, overall central bank profits will be affected if wealth is permanently held in high denomination banknotes rather than bank deposits, generating seigniorage.

The case of Switzerland seems to be particularly interesting when estimating the share of banknotes held as a store of value, both domestically and abroad.<sup>3</sup> Switzerland issues banknote denominations with one of the largest values in the world.<sup>4</sup> Moreover, the level of interest rates is among the lowest worldwide, both currently and historically, implying a low opportunity cost of holding cash. This fact, together with Switzerland's reputation as a safe haven that attracts investors especially in times of crisis, would lead one to expect a sizeable amount of cash which is held as a store of value for different motives. While the introduction of the euro has given rise to several cash studies for euro-area countries, papers on the demand for Swiss banknotes are scarce. The most comprehensive study by Andrist (1997) is now 20 years old and therefore covers neither the recent financial crisis nor the phase of low interest rates.

<sup>&</sup>lt;sup>1</sup> For instance, circulation of EUR 500 banknotes increased by over 10% from September to October 2008 in the euro area. In the US, where only quarterly data are available for the denominations, circulation of USD 100 banknotes increased by an extraordinary 7% over the last quarter of 2008. In Switzerland, circulation of the CHF 1000 banknote increased by over 12% from September to October 2008.

<sup>&</sup>lt;sup>2</sup> Currency in circulation still constitutes a sizeable share of monetary aggregates. While in Switzerland the share of total currency in circulation in M1 decreased from over 20% at the beginning of the 1990s to around 14% recently, the share in M3 actually increased from less than 7% to over 8%.

<sup>&</sup>lt;sup>3</sup> Typically, the methods employed in this paper lead to an estimate of the share of cash used for domestic transaction purposes. The residual would be the share of currency used for all other purposes, i.e., domestic hoarding and non-resident demand. The latter could be further separated into the share used abroad as a medium of exchange and store of value. As the Swiss franc does not seem to be used for transaction purposes in other countries (Andrist 1997), we interpret the residual as encompassing both foreign and domestic hoarding, or hoarding in short. We do not have any evidence on the respective shares nor do we try to estimate them within this study.

<sup>&</sup>lt;sup>4</sup> Printing of the 10'000 Singapore-dollar banknote stopped in October 2014 and it is being withdrawn from circulation. Thus, there seems to be only one banknote denomination still in circulation, which is larger than the CHF 1000 banknote: the 10'000 Brunei-dollar note, which is pegged one to one to the Singapore dollar and is currently worth around CHF 7'100.

Against this backdrop of only a few studies on the demand for Swiss franc currency, we investigate the demand for Swiss banknotes over the period from the inception of the Swiss National Bank (SNB) in 1907 to 2015. We start by providing a survey of the literature on the demand for Swiss currency and continue with stylized facts on the evolution of total banknotes as well as on the different denominations and put them into relation internationally. We then go on to estimate the potential amount of banknotes used as a store of value, or "hoarding" in short, focusing on the so-called seasonal method and emphasize specific issues when working with Swiss data. The seasonal method approximates non-transactions-related demand by relating the seasonal pattern of the banknotes of interest to the seasonal pattern of some reference series. This reference series can either be a smaller denomination banknote, banknote circulation in another country or other time series related to domestic transaction demand for cash. As hoarding should dampen seasonal pattern than the series of interest.

In the Swiss case, however, the denomination most likely used for hoarding purposes – the CHF 1000 banknote – shows a large, pronounced seasonal peak in December which exceeds the corresponding seasonal peaks for the smaller denominations and presumably occurs for other reasons than seasonal transaction demand. We try different methods to correct for this peculiarity. First, we try to estimate the "excess seasonality" of the CHF 1000 banknote, using institutional features of the Swiss tax system following Ettlin and Fluri (1986). The resulting corrected seasonal ranges, on which the seasonal method is based, do not lead to plausible estimates for the hoarding share of the CHF 1000 banknote, however. Second, we use different months to compute the seasonal ranges. The corresponding results indicate that since the turn of the millennium the share of CHF 1000 banknotes that is hoarded increased steadily from around 30% in the mid-1990s to over 70% in recent years.

The paper is structured as follows. Section 2 reviews the existing literature on Switzerland, which reveals a wide range of estimates for the hoarding share of banknotes. Section 3 presents some stylized facts on the evolution of Swiss banknotes over time as well as for the different denominations. Section 4 introduces the seasonal method, describes and rationalizes the pronounced seasonal pattern of the CHF 1000 banknote and explores different ways to apply the approach to the Swiss case. Section 5 summarizes and concludes.

### 2. Studies on the demand for Swiss franc currency

As indicated in the introduction, it is surprising that Swiss franc currency hoarding has not been much investigated, in contrast to other currencies like the US dollar or the euro (or its precursors). In the following, we survey the literature on the demand for Swiss franc currency, with a particular focus on results related to hoarding.

In general, one strand of the literature on currency demand starts with observations on the share of outstanding currency that is needed for transactions by using either payments data or conducting surveys. We are not aware of any such survey for Switzerland so that we have to resort to evidence collected for countries that might be similar to Switzerland in terms of currency demand. Based on payment diary data, Bagnall et al. (2016) conduct a

comprehensive study on cash usage in seven developed countries.<sup>5</sup> According to this data, the mean respondent carries cash balances of USD 123 in Germany and USD 148 in Austria in his wallet. Arguing that these countries have similar habits concerning cash as Switzerland, we could take them as a reference to extrapolate the currency stock needed for transactions. With a population of 8 million, this would result in a currency stock of roughly CHF 1.2-1.5 billion, i.e., only 2% of the banknotes that were actually in circulation at the end of 2015.<sup>6</sup> It is common, however, that households' transaction demand constitutes only a minor share of outstanding currency. Based on evidence from a 1986 currency holding survey, Sprenkle (1993) obtains a value of around 10% for the US. Deutsche Bundesbank (2016, p. 42) estimates that the share of euro banknotes held for transaction purposes in Germany is less than 10%.

However, it seems that Switzerland exhibits some idiosyncrasies in payment patterns that are not shared by its neighbors. While in Switzerland the number of debit terminals per 1000 inhabitants exceeds that in Austria and Germany, the number of non-cash transactions is significantly lower. Moreover, automatic teller machines (ATMs) in Switzerland typically distribute denominations up to the CHF 200 banknote,<sup>7</sup> which significantly exceeds the value of the denominations that are typically available at ATMs in other countries. There the largest denomination available is generally worth only about one half or one third of that available in Switzerland.<sup>8</sup> This indicates that Swiss consumers might carry significantly larger amounts of cash than consumers in Austria and Germany. Finally, about two thirds of the CHF 1000 notes that were in circulation in 2013 flowed back to the SNB during that year, indicating that large banknotes are actually used in transactions (see SNB Annual Report 2013, p. 55).<sup>9</sup> Even when allowing for these differences and doubling or tripling the amount of cash needed for transactions, we are still left with a large share of outstanding currency that is not explained by transaction demand. This implies that sizeable amounts are hoarded and used as a store of value for different reasons (see, e.g., Bartzsch et al., 2013b; Deutsche Bundesbank, 2016).<sup>10</sup>

Coming to studies which feature Switzerland and explicitly investigate hoarding demand, the majority of studies obtains a hoarding share of around 40% for the Swiss franc for the 1980s and the 1990s. An early study is Boeschoten (1992). He finds that in countries with large denomination banknotes hoarding demand accounts for a significant share. For Switzerland, he estimates that at the end of the 1980s, 45% of currency in circulation was hoarded.<sup>11</sup> From

<sup>&</sup>lt;sup>5</sup> Studies based on surveys and related diary data are often criticized for an inherent sample selection bias and a bias caused by participants responding strategically. In the case of surveys among consumers, also effects of the survey's design on the results have to be taken into account. Particularly evident in this regard is a high sensitivity or resistance among consumers to having to answer questions about their cash holdings (see, e.g., Jonker and Kosse 2009).

Values are converted into Swiss franc using the OECD's purchasing power parity rate for 2015 at <u>http://stats.oecd.org/Index.aspx?</u> <u>datasetcode=SNA\_TABLE4</u>, thereby controlling for the different price levels.

Recently, also CHF 1000 notes are becoming available at ATMs.

<sup>&</sup>lt;sup>8</sup> See Amromin and Chakravorty (2009), Figure 2, Table 1, and Table 4.

<sup>&</sup>lt;sup>9</sup> Please note in this regard that the same banknote can flow back to the SNB several times in a year. Moreover, anecdotal evidence points to the use of large banknotes, in particular, in the market for cars, cattle trade, and for cash payment of bank transfers at post offices to pay rents and insurance premiums, for example.

<sup>&</sup>lt;sup>10</sup> Based on survey evidence, Stix (2013) found that in ten Central, Eastern, and Southeastern European countries 44% of respondents with savings report that cash has a higher weight in their financial portfolio than bank products (in particular savings accounts).

<sup>11</sup> In 1970, this share was 35%.

1970 until 1989, hoarding contributed 1% to the annual growth in cash.<sup>12</sup> Andrist (1997) comprehensively studies money demand in Switzerland, while dedicating a chapter to the demand for cash. He uses different methods to discern the demand for transactions as well as hoarding, both domestic and foreign. Using a method based on the life span of different banknote denominations, he obtains a share of hoarding and non-resident demand in 1995 of 40%. Moreover, following Seitz (1995), he concludes that non-residents do not hold Swiss franc for transaction purposes but exclusively for hoarding. An internal SNB study (SNB 1998) uses the seasonal method with Sweden as a reference country. For the period from 1985 to 1997, the share of the demand for hoarding and non-resident demand of the Swiss franc is estimated to be about 40% on average.

Some studies, however, obtain much larger estimates of 70% or even more for the hoarding share of the Swiss franc. Based on an analysis of the seasonal patterns, Andrist (1997) calculates a share of 70% for domestic and foreign hoarding demand. Since he uses retail sales as reference series and the results are quite sensitive to the coefficient relating currency in circulation and retail trade, we would not put too much emphasis on these results. Moreover, Doyle (2000) estimates the foreign holdings of US, German, and Swiss currency over the time period from 1960 to 1996. Within a cointegration framework, he uses estimated currency demand functions of a reference country to obtain the predicted (domestic) currency demand of the particular country of interest and thereby an estimate for the foreign holdings. For the Swiss franc, he obtains non-resident holdings of 77% in 1996. However, as the author himself notes, the choice of Austria as a reference country for Switzerland is not fully convincing. Consequently, his results for Switzerland should be interpreted with caution.<sup>13</sup>

Moreover, some studies explicitly investigate the demand for certain denominations. Kohli (1988) estimates a system of demand equations for the different banknote denominations in Switzerland for the period from 1950 to 1984.<sup>14</sup> The model is used to predict the demand for a banknote, which had not been issued at the time: the CHF 200 bill. That denomination was actually issued in 1997 and with hindsight, Kohli's estimate for the share of CHF 200 banknotes was quite accurate. He predicted a share of 14.3% (given the CHF 500 banknote would be abolished), when it actually has been 14.5% on average since 1997. Ettlin (1989) investigates the demand for small (up to CHF 100) and large (CHF 500 and 1000) banknotes, respectively, within a cointegration framework. He takes particular account of the biannual tax effects and the hoarding demand resulting from measures to bypass capital controls imposed during the breakdown of the Bretton Woods system.<sup>15</sup> Based on just the latter effect, he obtains a hoarding demand of 23% of the large banknotes in circulation for the first

 $<sup>\</sup>overline{12}$  The average annual growth rate of banknotes in Switzerland over that period is 4.3%.

In their study of the euro area, Fischer, Köhler, and Seitz (2004) present stylized facts on Swiss cash demand and its seasonal pattern for comparison without providing estimates of a hoarding share.

<sup>&</sup>lt;sup>14</sup> Among the potential explanatory variables are a variable measuring the distance of the value of a denomination to its neighboring denominations, the physical size, the price level, income per capita, velocity, and an interest rate.

<sup>&</sup>lt;sup>15</sup> Capital controls, e.g. in the form of negative interest rates on deposits of non-residents of up to -10% per quarter were imposed as well as a ban on the acquisition of domestic financial assets by non-residents to address strong capital inflows. These measures were gradually phased out from 1979 onwards, after an exchange-rate target had been introduced at the end of the preceding year; see also SNB (1982, pp. 290f) and SNB (2007, pp. 195-198).

quarter of 1980; a corresponding hoarding demand is not apparent for the small denominations.

Finally, Fischer (2014) investigates the effect of immigration on the demand for large banknotes in Switzerland using micro data. He finds that natives hoard more CHF 1000 banknotes than immigrants. While this is inconsistent with the hypothesis that immigrants use cash for remittances or have less access to banking services, it is consistent with tax avoidance or a particular distribution of characteristics that are relevant for precautionary money demand (e.g., immigrants on average being of lower age or having lower wealth than natives). However, the results do not allow for a discrimination between these effects.

# 3. Stylized facts on the demand for banknotes in Switzerland

In order to get an overview of the different characteristics of cash demand in Switzerland, we present some stylized facts on the demand for Swiss franc banknotes, both for the total and the different denominations. This allows us to get a sense of the relevance of banknote hoarding over time and of the importance of different denominations in this context.

#### 3.1. Demand for total banknotes

When the SNB started to operate on 20 June 1907, it issued its first own banknotes.<sup>16</sup> On that day, SNB banknotes of a total value of CHF 44.2 million were in circulation.<sup>17</sup> This amounted to 23.3% of the total value of banknotes in circulation (SNB 1932, p. 56), while the remainder was made up of notes of the banks of issue. Over the next three years, these two sets of banknotes circulated in parallel, with an increasing share of SNB banknotes. When the transition was completed in June 1910, the value of total (SNB) banknotes in circulation had increased to CHF 254.9 million.

Figure 1 shows annual data for the nominal value of total banknotes in circulation in Switzerland from the inception of the SNB in 1907 to 2015. The left-hand panel indicates that it increased steadily from around CHF 0.16 billion at the end of 1907 to CHF 72.88 billion at the end of 2015. From the end of the transition period in 1910 to 2015, the average annual growth rate of banknotes in circulation was 5.4%. This is larger than the average annual increase in nominal GDP over that time period, which was 4.8%. Given technological progress in payment technologies and cash management practices, a smaller average growth rate of banknotes than of nominal GDP would be expected. Thus, other factors also seem to have played a role. In particular, as the right-hand panel of Figure 1 shows, the growth rates have been quite different over the years. The first 30 years saw a large volatility in banknote circulation. During four years, banknote circulation even increased by more than 30%, namely during World War I (1914, 1917, and 1918) and when the Great Depression

<sup>&</sup>lt;sup>16</sup> During that time, Switzerland was part of the Latin Monetary Union (de facto on a gold standard from the early 1870s), which regulated issuance and acceptance of coins among participating countries, but not of banknotes. Before 1907, Switzerland had no central bank but operated within a system of free banking, where private banks ("banks of issue") issued banknotes and competed with each other. Until 1881, the issuance of banknotes was not even regulated by the Swiss government. See SNB (2007, pp 29-35).

<sup>&</sup>lt;sup>17</sup> As the time to develop and produce the SNB's first own banknote series (called "interim banknotes") was limited, it built on the banknotes issued by the private banks of issue: it used the same paper and printing plates, where the number of the bank of issue on each denomination was replaced by a rosette with Swiss cross. Also the denominations were the same as regulated and standardized by the Swiss law on banknotes from 1881 (cf. Section 3.2).

intensified in 1931.<sup>18</sup> In all of these instances, hoarding demand for Swiss franc also from non-residents was an issue, so that from May 1918 to June 1921 a ban on Swiss franc shipments abroad was imposed. Between these large peaks, banknote circulation decreased in several years, in particular in the first half of the 1920s and again from 1933 to 1935. There were different reasons for this. In the former period, banknotes that were hoarded abroad flowed back when the German hyperinflation had been stopped (SNB 1932, p. 137). Moreover, gold coins and banknotes circulated in parallel, which made the demand for banknotes dependent on the availability of gold coins (SNB 1932, p. 142), which itself was volatile and affected by global shocks.

The years of World War II saw again a strong increase in the demand for Swiss franc banknotes. It flattened in the 1950s but returned to higher growth rates during the years of higher inflation in the 1960s and particularly in the 1970s. Towards the end of the Bretton Woods system, and again during the late 1970s, Switzerland experienced large capital inflows and in response resorted to capital controls, in particular negative interest rates on deposits held by non-residents. As banknotes were used to circumvent those capital controls, these periods of increased appreciation pressures are visible in the two peaks during the 1970s in the right-hand panel of Figure 1. The 1980s and most of the 1990s featured slower banknote growth, which then accelerated with the uncertainties and crises since the end of the 1990s, namely the fear of a possible millennium bug 2000, the bursting of the dot-com bubble around 2000, the 9/11 terrorist attacks in 2001, the introduction of euro banknotes and coins in 2002, the financial crisis in 2008, and the euro area debt crisis starting 2010.

The (nominal) demand for banknotes increased strongly over time also in per capita terms. Figure 2 shows that banknotes per capita and total banknotes increased in lockstep, so that population growth does not seem to be an important factor driving banknote demand. Total (nominal) banknote holdings per capita increased from CHF 80 in 1910 to almost CHF 8800 in 2015. This translates into an average annual increase of 4.6%, whereas population growth was only 0.8% p.a. on average over that time period. A similar picture emerges when considering banknote holdings per capita in real terms.<sup>19</sup> Real per capita banknote holdings, in prices of 2015, increased from CHF 1430 in 1921 to almost CHF 8800 in 2015, i.e., by 1.9% p.a. on average, whereas real total banknote holdings increased by 2.8% p.a. on average (cf. Figure 3).

Also in international comparison, banknote holdings per capita in Switzerland are high, as Table 1 documents. The only country coming close is Japan. In Swiss franc, Japan's per capita holdings are 27% lower than Switzerland's, but in PPP terms, they are around 7% larger.<sup>20</sup> The US and the euro area, both being large currency areas for which the literature has estimated a sizeable share of banknotes circulating abroad,<sup>21</sup> have holdings at around 60% of the Swiss ones in PPP terms. Whereas the UK and Canada are in a range of 20-25%

That year saw a sharp deterioration of the economic situation particularly in neighboring Austria and Germany, following the failures of Creditanstalt and Darmstädter und Nationalbank (Danat), respectively.

<sup>&</sup>lt;sup>19</sup> This series is only available from 1921 onwards due to lacking price data.

<sup>&</sup>lt;sup>20</sup> Following the strong appreciation of the Swiss franc since 2008, total banknotes per capita in Swiss franc tend to overstate holdings in Switzerland relative to other countries.

<sup>&</sup>lt;sup>21</sup> See, for example, Fischer et al. (2004), Porter and Judson (1996), or Seitz (1995).

of Swiss banknote holdings, Sweden is at the lower end with only about one tenth of that of Switzerland's. Relative to GDP, the position of Switzerland remains basically the same as in per capita PPP terms, confirming that the choice of normalization does not affect the conclusion that Swiss banknote holdings are high.

Standard monetary theory implies that the demand for banknotes should depend on the volume of transactions, the price level, and the opportunity cost of holding cash. We therefore plot the ratio of total banknotes to (nominal) GDP, i.e., the inverse of the velocity of banknotes in circulation, in the left-hand panel of Figure 4, together with the interest rate on savings deposits as a measure of the opportunity cost. Compared with banknote holdings per capita (Figure 2), the ratio of banknotes to GDP shows a different pattern. From the establishment of the SNB until 1945, the ratio of banknotes to GDP increased with a brief fallback in the 1920s. This matches with the evidence reported above that political uncertainty and demand from abroad led to increased hoarding. After reaching a peak of over 25% in 1945, the ratio of banknotes to GDP fell steadily – with only a brief interruption in the early 1970s – until the beginning of the 1990s when it reached a level of about 7.5%. Such a downward trend would be expected if advances in payment technologies lead to a larger share of non-cash payments and if cash management improved. Until the beginning of the recent financial crisis, the ratio of banknotes to GDP moved sideways whereas, since 2008, it started to increase again. Initially, both a fall in GDP in the course of the crisis and an increased demand for banknotes due to doubts about the solidity of banks contributed to this increase. However, even after GDP started to grow again and the most severe banking problems had abated, the ratio continued to increase and reached over 11% in 2015.

A qualitatively similar picture for the post-war years emerges when relating total banknotes to private consumption, as indicated in the right-hand panel of Figure 4.<sup>22</sup> This transactions-related variable is presumably more relevant for banknote demand, compared to the more broadly defined concept of GDP. Nevertheless, also for the ratio to private consumption, a downward trend up to the early 1990s is observed, which was briefly interrupted in the late 1970s. From the early 1990s to the recent financial crisis the ratio bottomed out, but passed over to a strong increase, particularly since 2012. In 2015, the ratio stood at 21%, a level last seen in the late 1970s.

Barring secular trends that are driven by advances in payment technology or other lowfrequency developments, we would expect a negative relation between the ratio of banknotes to consumption or GDP and the opportunity cost of holding cash. To some extent, this is indeed the case. The increase in the banknote-to-GDP ratio in the late 1970s coincides with a downward spike in interest rates. Moreover, the sharp increases in interest rates in the late 1980s to the early 1990s led to an acceleration of the decrease in the banknote-to-GDP ratio. However, much of the decrease in interest rates took place in the late 1990s whereas the banknote-to-GDP ratio picked up strongly only after the financial crisis in 2008. This is reflected in the correlation of the interest rate with the deviation of these ratios from trend.<sup>23</sup>

<sup>&</sup>lt;sup>22</sup> Unfortunately, annual data on private consumption for Switzerland is only available since 1948.

<sup>23</sup> As a first approximation, we try to capture the aforementioned secular movements, which might include advances in payment technology but also long-run trends in hoarding demand, by the trend resulting from an application of the Hodrick-Prescott filter to those ratios. For

Considering the banknote-to-GDP ratio, the correlation is indeed negative at -0.12 for the whole period from 1907 until 2015. Over the post-war period starting 1948, the correlation is more strongly negative at -0.26. However, as indicated above, when considering the sample from the second half of the 1990s until 2015, it turns positive with 0.07.<sup>24</sup> Obviously, there have been other factors besides interest rates which have influenced this ratio in the course of time.

In sum, demand for Swiss franc banknotes has increased steadily since the establishment of the SNB in 1907. Until the end of World War II, hoarding demand, also from abroad, has recurrently played a role. With the Bretton Woods agreement, the US dollar became the dominant currency and motives for hoarding Swiss francs apparently receded. Nevertheless, Switzerland's stability, low inflation, and the existence of a large value banknote presumably make Swiss franc banknotes still attractive for hoarding. The strong increase in banknote demand in the wake of the financial crisis supports this conjecture. We now turn to the different denominations in order to uncover more evidence.

#### **3.2.** Evolution of different banknote denominations

The first banknote series issued by the SNB contained only denominations of CHF 50, 100, 500, and 1000. The value of the banknote denominations in real terms in the early 1900s was high, in particular when considering that the price level has increased about fivefold from 1920 until 2015. Banknotes were mainly employed in commercial transactions, which explains their relatively large value.<sup>25</sup> Typically, (gold and silver) coins were used in day-to-day transactions. In conjunction with the beginning of World War I and a resulting drop in the circulation of coins, banknote denominations of CHF 5 and CHF 20 were added in 1914 to provide sufficient means of payment for day-to-day operations.

About 40 years later, i.e., in 1956, the CHF 10 banknote was issued as the next new denomination. Issuance of the CHF 5 banknote was suspended subsequently in 1958 and its circulation became negligible shortly afterwards. In 1997, the CHF 500 banknote was replaced by a CHF 200 banknote, so that the current set includes the following six denominations: CHF 10, 20, 50, 100, 200, and 1000.<sup>26</sup> As a result, the replacement of the CHF 500 by the CHF 200 banknote takes place during our sample period and has the potential to affect the demand also for the other denominations.

Figure 5 shows that the increase in the nominal value of banknotes in circulation since 1956 is mostly driven by the large denominations, predominantly the CHF 1000 and CHF 500 bills up to 1980 and only the CHF 1000 bill thereafter. Their value shares increased particularly

the banknote-to-GDP ratio, this trend first increases from the beginning of the sample in 1907 until the end of World War II, then decreases again until the mid-1990s. Subsequently, it is stable until the beginning of the recent financial crisis, when it increases again.

<sup>24</sup> Similar correlations are obtained when using the banknote-to-consumption ratio.

<sup>&</sup>lt;sup>25</sup> During the first ten years of the SNB, changes in payment technology, namely the replacement of trade bills by settlement in banknotes, led to an increase particularly in the demand for CHF 1000 banknotes, see SNB (1932, p. 136).

The SNB reviews the set of denominations regularly. Against the backdrop of weak demand for CHF 500 banknotes, i.e., the demand for the CHF 500 banknote basically stagnated since the mid-1970s and its share in the total value of banknotes had been declining since 1975, the SNB in 1985 considered two possible future sets of denominations: one with *both* a CHF 200 and 500 bill and another with *either* a CHF 200 and 500 bill. Banks and business representatives had a preference for the latter solution and also experiences abroad pointed in that direction. Moreover, printing an additional denomination is costly. As a result, in 1987 the SNB decided to replace the CHF 500 banknote by a CHF 200 bill. See SNB (2007, p. 346).

over the 1970s, when they were used to bypass measures to limit appreciation pressure on the Swiss franc in the course of the breakdown of the Bretton Woods system.<sup>27</sup> The popularity of the CHF 500 banknote declined from the end of the 1970s onwards. This coincides with the introduction of banking accounts related to wage payments over the course of the 1970s, so that fewer and fewer wages were paid in cash,<sup>28</sup> where the CHF 500 bill had been a popular denomination. This change in the payment technology also affected the CHF 100 banknote. It was the most important bill up to the early 1970s, but exhibited a sharp drop in its share over the following decade. The CHF 1000 banknote, in contrast, continued its upward trend – even despite an increased popularity of payments by check (Swiss-Check) – and reached a value share of 62% in 2015. The introduction of the CHF 200 banknote in 1997 led to some modifications in the distribution among the different denominations. First, the CHF 500 banknote quickly dropped out of circulation and the demand was picked up by the new CHF 200 banknote, but also by the CHF 1000 bill. Second, some of the demand for CHF 100 banknotes has been on a declining trend since then.

The fact that the noticeable increase in the demand for total banknotes is driven by the largest denomination and that its share dominates those of the other denominations is a first indication that a non-negligible part of the increased demand for the CHF 1000 bill might result from hoarding, domestically or abroad.<sup>29</sup>

In addition, Figure 6 illustrates that only the CHF 1000 banknote shows an unambiguous increase in its ratio to consumption over the sample period.<sup>30</sup> By contrast, for the CHF 100 bill this ratio fell continuously from over 13% in 1956 to less than 3% at the end of the 1990s. The CHF 500 banknote and the smaller denominations also fell strongly in importance until the end of the 1990s, after which they flattened out. By contrast, since the recent financial crisis, the ratios to consumption for the CHF 100 and the CHF 200 banknotes increased slightly, which might indicate some hoarding demand also for these denominations.

In general, the developments of the different banknote denominations relative to consumption are consistent with advances in payment technologies, more efficient cash management practices, as well as changes in payment habits (e.g., wages are no longer paid in cash but instead in a bank account, increased payments by credit and debit cards, etc.) and indicate that denominations up to CHF 50 are primarily used for transaction purposes. The CHF 1000 bill, in particular, plays a different role. From 1956 until the late 1990s, the ratio to consumption for the CHF 1000 banknote fluctuated in a band between 6% and 9%. From the mid-1990s on, this ratio embarked on a rising trend and stood at 13% in 2015. Again, these figures illustrate that the main vehicle for banknote hoarding seems to be the CHF 1000

<sup>&</sup>lt;sup>27</sup> See footnote 15.

The number of postal checking accounts more than doubled between 1970 and 1980, mainly due to accounts related to wage payments.
 See SNB (1982, pp. 290 and 295). The average (gross) monthly wage in 1970 was about CHF 1500.

<sup>&</sup>lt;sup>29</sup> Fischer et al. (2004, p. 14f) refer to the high share of large denomination banknotes in Germany, the Netherlands, Belgium, and Austria as an indication of hoarding. However, they do not quantify this observation. Van Hove and Vuchelen (1999) show for the case of Belgium that the introduction of a new highest denomination leads to a substitution of hoarding away from the lower denominations.

A similar picture emerges for the banknote-to-GDP ratio as presented in Figure 7.

banknote (and to a smaller extent the CHF 200 and potentially the CHF 100 banknote), so that in the following we will focus on this denomination.

# 4. The seasonal pattern of CHF 1000 banknotes and hoarding demand

In this section, we study the seasonal pattern of different banknote denominations with the aim to determine the demand for hoarding, following Sumner (1990) and Porter (1993).<sup>31</sup> The basic idea behind the method based on seasonal patterns is that banknote demand for (domestic) transactions is influenced by events that occur regularly over the year like Christmas shopping or summer holidays. By contrast, banknote demand for hoarding (or foreign demand) is typically not affected by such seasonal factors. As a result, the seasonal variation of banknote demand will decrease with an increasing share of banknotes that are hoarded or held by non-residents.<sup>32</sup>

#### 4.1. Seasonal method

More formally, total banknote demand can be modeled as the product of a trend-cycle component,  $T_t$ , and a seasonal component,  $S_t$ . This decomposition also holds for the domestic-transactions  $(T_t^{tr})$  and non-domestic-transactions  $(T_t^{ntr})$  related demand, respectively:<sup>33</sup>

$$T_t S_t = T_t^{tr} S_t^{tr} + T_t^{ntr} S_t^{ntr}.$$
(1)

Next, let  $\beta_t$  be the share of the overall trend-cycle component demanded for domestic transaction purposes, and  $(1 - \beta_t)$  be the share demanded for hoarding or by non-residents. This leads to

$$T_t S_t = \beta_t T_t S_t^{tr} + (1 - \beta_t) T_t S_t^{ntr}.$$
(2)

This equation can be further simplified by cancelling  $T_t$  from both sides of the equation and assuming that the demand for hoarding and by non-residents does not exhibit seasonal variation, i.e.,  $S_t^{ntr} = 1 \forall t$ :

$$S_t = \beta_t S_t^{tr} + (1 - \beta_t). \tag{3}$$

When solving for  $\beta_t$ , this equation would – based on estimated seasonal factors from standard seasonal-adjustment packages – in principle yield a time-series for the hoarding share.

$$\beta_t = \frac{S_t - 1}{S_t^{tr} - 1}.\tag{4}$$

As can be seen from equation (4),  $\beta_t$  will be close to zero when the seasonal factor for a certain month is close to unity, whereas it might be very large (or undefined) whenever the

<sup>&</sup>lt;sup>31</sup> There are different methods to estimate hoarding of a given currency, see Fischer et al. (2004) as well as Bartzsch et al. (2011a, 2011b) for an overview.

 <sup>&</sup>lt;sup>32</sup> Nevertheless, seasonal influences are possible in the case of small denominations used for foreign travel. However, the share of foreign demand affected by this is likely to be fairly limited in relation to the total volume of banknotes circulating outside Switzerland or being held for hoarding purposes.

 <sup>&</sup>lt;sup>33</sup>Of course, a seasonal adjustment decomposition also entails the irregular component. For the purpose of this investigation, we fold the irregular component into the trend-cycle component. Having a separate irregular component does not alter the results.

seasonal factor of the reference series approaches one. To make these estimates more robust, a range (e.g., the maximum) of seasonal factors within one year is therefore usually used.<sup>34</sup> Inserting, for instance, the highest and lowest seasonal factors into equation (3) gives:

$$S_{max,t} = \beta_t S_{max,t}^{tr} + (1 - \beta_t)$$
  

$$S_{min,t} = \beta_t S_{min,t}^{tr} + (1 - \beta_t).$$
(5)

When subtracting the two equations from each other and solving for  $\beta_t$ , we obtain an estimate of the share of banknotes held for domestic transaction purposes in year *t*:

$$\beta_t = \frac{S_{max,t} - S_{min,t}}{S_{max,t}^{tr} - S_{min,t}^{tr}}.$$
(6)

However, the seasonal factors for the purely transactions-related series,  $S_t^{tr}$ , are unknown and have to be approximated through the use of a benchmark series. The challenge is to find a suitable benchmark series to determine the range of seasonal factors related to domestic transactions, which cannot be observed directly. Possible choices are the demand for banknotes in a reference country, which does not feature hoarding and demand by non-residents or a variable like retail trade or private consumption expenditures that is solely related to domestic transactions.<sup>35</sup> Alternatively, the seasonal factors across different denominations can be compared, assuming that small denominations are mainly used for transactions, whereas large banknotes are more prone to hoarding and non-resident demand.<sup>36</sup>

In the case of Switzerland, however, finding a suitable reference series is difficult. When using banknote data from another country, ideally, this reference country should feature a similar pattern for banknote demand except that there is no hoarding and foreign demand. In the past, Sweden was considered a reasonable reference country for Switzerland but this does not seem to be the case for more recent data. Fischer et al. (2004, p. 54) calculate the seasonal factors for Sweden and Switzerland from 1980 to 2000. Both countries showed a pronounced seasonal peak in December and no visible peak in the summer months. More recent data for Sweden, however, exhibit noticeable seasonal movements in the summer months, which does not conform with the Swiss pattern anymore. Alternative potential candidates (e.g., Denmark or the UK) exhibit similar problems, while other countries which are more similar with respect to banknote use, like Germany or Austria, also feature demand for hoarding and by non-residents, thereby making them ineligible as a reference country.<sup>37</sup>

Using private consumption or retail sales as reference series, however, also entails problems. First, private consumption data is available at quarterly frequency only, starting 1980. Moreover, its seasonal pattern is less pronounced than the one for banknotes, which rules out using the seasonal method to estimate hoarding and foreign demand. Second, retail sales are

<sup>&</sup>lt;sup>34</sup> See, for instance, Porter and Judson (1996) and Bartzsch et al. (2013b). Also, seasonal patterns at different frequencies could be used, for instance the intra-weekly, intra-monthly, or intra-yearly seasonal component. See, for example, Cabrero et al. (2002). In line with the literature, we employ the intra-yearly component.

 <sup>&</sup>lt;sup>35</sup> In principle, domestic hoarding and non-resident demand could be separated if a reference country could be found with a similar hoarding demand but no demand by non-residents or vice versa. In practice, it is hardly possible to distinguish the two components. However, Bartzsch et al. (2013b) present one possibility relying on different seasonal patterns for the case of Germany.

<sup>&</sup>lt;sup>36</sup> For an overview of other alternatives like coins or vault cash, see Bartzsch et al. (2013b) and Seitz (1995).

<sup>&</sup>lt;sup>37</sup> The introduction of the euro presents an additional complication for these countries.

available on a monthly basis, but only since 2002. This would shorten our sample period considerably.

Therefore, we focus on the comparison of different banknote denominations. We concentrate on those denominations which are present over the entire sample under consideration, i.e., from 1956 to 2015.<sup>38</sup> This eliminates the CHF 200 and 500 banknotes, which were either introduced only later or abolished earlier, respectively. We also abstract from the CHF 10 banknote, introduced in 1956, to limit the boundary problem related to the seasonal filter. As a result, we are left with the CHF 20, 50, 100, and 1000 banknotes, which account for around 83% of banknotes in circulation on average over the sample period (in value terms). Figure 8 to Figure 11 show their seasonal patterns. On the left-hand panel, the seasonal factors are plotted as time series whereas the right-hand panel shows the same seasonal factors, just in a different ordering, i.e., for a given month over the entire sample period, in order to get an impression of the typical seasonal range in the series.

What immediately becomes apparent from these figures is the pronounced seasonal pattern of the largest banknote denomination compared to the smaller denominations. As indicated in the previous chapter, we would expect hoarding demand to be concentrated in the demand for CHF 1000 banknotes, which would imply that the seasonal variation is dampened compared to those bills which are typically used for transactions. However, this is not the case here. The CHF 1000 banknote is characterized by the largest seasonal factors, particularly in December, though the December peaks have decreased visibly since the mid-1990s and again after the financial crisis. By contrast, the smaller denominations show an increase in the December peak around the early 2000s, which for the CHF 100 banknote has reversed since the financial crisis as well. In the earlier part of the sample, a continuous increase in the seasonal lows at the start of each year is visible for the CHF 100, 50, and 20 denominations. While the cause for the less pronounced troughs is unclear, this development came to an end in the late 1970s when ATMs started to appear and may have led to a smoother demand for precautionary as well as transaction balances.

Overall, comparing Figure 8 with those of the smaller denominations illustrates that the CHF 1000 banknote features a maximum seasonal range, which is larger than that of all the other denominations.<sup>39</sup> This basically renders the standard seasonal approach to estimate hoarding and non-resident demand, as described above, inapplicable.

#### 4.2. Correction for tax effects

As indicated above, the main cause for the extreme seasonal variation of the CHF 1000 banknote is the very large peak in December. Even though one would expect a seasonal peak at the end of the year because of Christmas shopping and gifts in terms of money, also other influences seem to be at work, especially end-of-year tax considerations. Switzerland is one of only a few countries in Europe that taxes wealth, which includes deposits held in bank

<sup>&</sup>lt;sup>38</sup> The sample size basically results from the program limitations of the seasonal adjustment package X-13ARIMA-SEATS.

<sup>&</sup>lt;sup>39</sup> For the CHF 1000 banknote, the seasonal high is reached in December, whereas the seasonal low is in August.

accounts.<sup>40</sup> Taxable wealth can easily be reduced by withdrawing deposits prior to the end of the year and re-depositing them at the beginning of the next year, as bank statements issued for tax purposes show only the balance on December 31<sup>st</sup>.<sup>41</sup> Such a behavior would result in a pronounced seasonal peak in the demand for large banknotes in December. Consequently, the maximum seasonal range for the CHF 1000 banknote including December would be biased upward due to a temporary non-transactions-related component from which we want to abstract.

Ettlin and Fluri (1986) present evidence that tax effects indeed play a role for the pronounced December peak in the demand for CHF 1000 banknotes. They document a biannual regularity in the December peak, which they attribute to the biannual tax period that was common in most cantons until 2000.<sup>42</sup> More specifically, up to that year, the relevant time period for tax statements was two years (instead of one), beginning with an odd-numbered year. As a result, every two years a related increase in the demand for banknotes could be observed, i.e., at the turn of the year from an even- to an odd-numbered year. Therefore, until around 2000, two subsequent December peaks are of considerably different size and the difference varies over time as the tax legislations of the cantons changed.

We follow the methodology suggested by Ettlin and Fluri (1986) to take these biannual effects into account in the seasonal adjustment procedure for the CHF 1000 banknote series. The idea is to split the time series into two series: one containing only the odd-numbered months and one containing the even-numbered months. Standard seasonal filters are then applied separately to these two series. As the seasonal adjustment procedure still filters out seasonal variation over twelve time periods, this means that in effect both series are adjusted for biannual seasonal variation. Subsequently, they are recombined (and re-normalized) to obtain one series. With this methodology, a given month in two subsequent years (e.g., the December in year t and the December in year t+1) is treated differently, in contrast to standard approaches. This allows us, in particular, to capture the large seasonal December peak every two years due to tax reasons. The corresponding effect is also visible in the seasonal factors presented in Figure 8.

Following this approach, the average difference between the December peak of an oddnumbered year and the subsequent even-numbered year is 2.9% from the beginning of the sample until 2000, when the last cantons phased out biannual tax collection. The largest (absolute and percentage) difference between subsequent December peaks occurred in 1983/84: The seasonal factor for December 1983 is 1.0725, whereas it is 1.1300 for December 1984, an increase of 5.4% from the odd- to the even-numbered year.<sup>43</sup> This gives

<sup>&</sup>lt;sup>40</sup> Currently, there is a wealth tax at the level of the cantons and the municipalities, but not at the federal level; the federal tax on wealth was abolished in 1959. Though the wealth tax does not range among the most important taxes, its proceeds accounted for 8.5% of the tax income of cantons and municipalities in 2013, see Eidgenössische Steuerverwaltung (2016).

 <sup>&</sup>lt;sup>41</sup> Strictly speaking, also cash holdings are part of the taxable wealth and have to be declared. However, they are difficult to verify for the tax authorities.
 <sup>42</sup> The factor of the taxable wealth and have to be declared. However, they are difficult to verify for the tax authorities.

<sup>&</sup>lt;sup>42</sup> The Swiss parliament issued a law in 1993 that required the cantons to harmonize the methodology according to which the wealth tax is collected. Thus, in the years until 2000, the cantons with a biannual tax collection period had to phase out this scheme. The variation of tax rates and exemption amounts among different cantons and municipalities remains nevertheless high, see Eidgenössische Steuerverwaltung (2016).

<sup>&</sup>lt;sup>43</sup> This is after re-normalization to ensure an average seasonal factor of one over each year.

us an estimate of the tax-induced increase in the demand for CHF 1000 banknotes. However, given that not all cantons applied a biannual tax-collection period and that the tax legislation changed over time, these estimates constitute only a lower bound for the true seasonal increase in the demand for CHF 1000 banknotes due to tax reasons.

Nevertheless, we try to estimate the magnitude of the tax-related bias in the demand for CHF 1000 banknotes from the difference in subsequent December peaks. Since this difference varies over time, we take this into account in our correction procedure. In particular, until 1998, we replace the (excessive) seasonal factor for December in an evennumbered year by the average of the seasonal factors for December in the two adjacent oddnumbered years, i.e., by the average of the seasonal factors of the preceding and subsequent year. This leads to an average reduction in the seasonal factor for December of 2.9%. Since the biannual tax pattern ended in 2000, we cannot use the aforementioned procedure to correct the December peaks from that year onwards.<sup>44</sup> The resulting series of seasonal factors can be found in the left-hand panel of Figure 12, whereas the original series already presented in Figure 8 is reproduced here in the right-hand panel for comparison.

Whereas the seasonal peaks in December are reduced, sometimes considerably, the maximum seasonal range is still large when compared to those of the smaller denominations presented in Figure 9 to Figure 11. According to the hypothesis underlying the seasonal method, this would imply that CHF 1000 banknotes are predominantly used for transactions whereas the smaller denominations are hoarded, which obviously does not conform with observed payment patterns.<sup>45</sup> One problem with our correction for tax avoidance, for instance, is that we only capture tax avoidance in cantons with biannual tax periods, whereas we do not correct for cash withdrawals in cantons with annual tax periods. We therefore resort to another approach and employ different seasonal ranges that leave out the December peak.

#### 4.3. Using alternative seasonal ranges

In the spirit of Porter and Judson (1996), we start from the seasonal range observed over the time period which best corresponds to the maximum seasonality in a transactions-related variable, e.g., retail sales. For this variable, the seasonal high is reached in December and the seasonal low in February, in line with international evidence on the seasonality of transactions. Since we want to abstract from the excessive seasonal peak of the CHF 1000 banknote in December, we take the January as a proxy. This month features the second-largest seasonal factors and, since these are end-of-month figures, presumably the tax-related withdrawals have already been deposited again. As a reference series, we take the CHF 20 banknote and not the CHF 10, since the latter was only introduced in 1956 whereas the CHF 20 banknote already appeared in 1914. As a result, we can study a longer

<sup>&</sup>lt;sup>44</sup> Please note that after 2000, there is now an annual tax period (instead of biannual), so that one should expect the additional, tax-related banknote demand in December to occur every year (instead of every two years).

 <sup>&</sup>lt;sup>45</sup>When applying the seasonal method, in this subsection we use the maximum seasonal range of the reference series as well as of the series of interest to compute the hoarding shares. Using other ranges, but still including December, does not fundamentally alter the results.

time period and, moreover, reduce the boundary problem related to the seasonal filter.<sup>46</sup> Moreover, the maximum seasonal range of the CHF 20 banknote perfectly corresponds to that of retail sales, i.e., the peak is in December, whereas the low is in February. This is a further indication that the CHF 20 banknote is primarily used for transaction purposes. The seasonal factors for these two denominations can be found in Figure 8 and Figure 11.

The main results of this analysis are presented in Figure 13. It shows the share of hoarding demand for the CHF 1000 banknote, i.e., formally  $(1 - \beta_t)$ . More specifically, we focus on longer-run movements and average the respective seasonal ranges of the target and reference series over a five-year horizon and plot the resulting estimated hoarding shares for the CHF 1000 banknote. After moving around 50% at the beginning of the sample, the hoarding share decreased to 45% at the end of the 1960s. Over the following two five-year periods, coinciding with the breakdown of the Bretton Woods system and related pressure on the Swiss franc, the estimated share increased again to 50%. More tranquil times followed, so that a low was reached from the mid-1980s to the mid-1990s with a hoarding share of 33% to 35%. In the course of the increased uncertainty due to the events since the turn of the millennium (millennium bug, 9/11, introduction of the euro), the hoarding share almost doubled to 64%, after which it stabilized until the beginning of the financial and euro area crises. The latter events led to a further increase in the share of hoarding to 73% in the last five-year period up to 2015.

The resulting nominal values, based on the average value of CHF 1000 banknotes in circulation over the respective five-year period, are presented in Table 2. In the first three five-year periods, even though the relative hoarding share fell, the absolute value of CHF 1000 banknotes hoarded almost doubled to around CHF 1.5 billion on the back of an increase in overall demand for CHF 1000 banknotes. During the breakdown of the Bretton Woods system, included in the following two five-year periods, this value further tripled to CHF 4.6 billion, after which it basically stagnated over the following 15 years until 1995. Since then, it increase in this latter episode occurred around the turn of the millennium (CHF 5.6 bn, 64%), while the second increase coincided with the period of the financial and euro area crises (CHF 11.7 bn, 69%). Considering the entire sample period from 1956 to 2015, the estimated value of CHF 1000 banknotes held for transaction purposes grew broadly in line with private consumption expenditures.

Overall, the hoarding shares obtained for the CHF 1000 banknote are within the range typically obtained for other large denomination banknotes. For example, estimates for the USD 100 note by Judson (2017) indicate that 60–75% of that denomination were held abroad at the end of 2016. Porter and Judson (1996) obtained a corresponding share of 66–75% for December 1995. For Japan, Otani and Suzuki (2008) found that just 40% of the JPY 10'000 banknotes were hoarded in 2007. Bartzsch et al. (2013b) analyze the net issuance of the Deutsche Bundesbank within the Eurosystem to get an idea of the proportions used for domestic transactions, hoarding, and foreign demand. They found that the EUR 500

<sup>46</sup> Using a shorter sample period, results based on the CHF 10 banknote do not differ much from those using the CHF 20 banknote as a reference series.

banknote, which is especially prone to hoarding, is the denomination most frequently held outside the euro area, i.e., EUR 95 billion out of an estimated total of German banknotes abroad of EUR 175 billion. Before the introduction of the euro, the Netherlands had a NLG 1000 banknote<sup>47</sup> for which Boeschoten and Fase (1992) obtained a hoarding share of 60–80% for the second half of the 1980s, depending on the method employed.

# 5. Summary and conclusion

In this study, we use the seasonal method to estimate the share of Swiss banknotes in circulation that is hoarded, both domestically and abroad. Compared to other countries, the application of this methodology to the Swiss case faces the problem that the largest denomination, the CHF 1000 banknote, exhibits very pronounced seasonal peaks that exceed those of other transactions-related time series, like small-denomination banknotes or private consumption expenditure, that are commonly used to proxy transactions-related banknote demand.

We present evidence that the large seasonal peak at the end of the year is related to tax effects, in particular, the wealth tax that is levied – among other things – on the end-of-year bank-account balances. For the time when this tax was levied biannually, we can estimate a correction for this tax effect. Applying this correction, however, is not sufficient to reduce the seasonal peaks in the CHF 1000 banknote series to levels below those of the references series.

To obtain a meaningful hoarding share, we therefore proxy the December peak of the CHF 1000 banknote and calculate the seasonal range based on the subsequent month, i.e., January. In this way, we obtain hoarding shares of around 50% until the early 1980s that then fall continuously to about 30% in the late 1990s. Subsequently, following the increased uncertainty since 2000 and, in particular, since the financial crisis in 2008, the share of hoarding for the CHF 1000 note has significantly increased to over 70%. These figures are within the range typically obtained for other large denomination banknotes.

In line with other countries and studies, our results show that only a small part of currency in circulation in Switzerland is used for transaction purposes. As this purpose is the most important one for economic and monetary policy reasons, the different motives and their magnitudes should be taken into account when interpreting monetary data. This should help to improve the indicator properties of monetary data for price and business cycle developments (see Aksoy and Piskorski, 2005, 2006, for the US).

 $<sup>\</sup>overline{47}$  This corresponds to more than EUR 450 at the official exchange rate irrevocably fixed at the end of 1998.

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# 7. Tables and Figures

	Total banknote	Total banknotes to		
	in CHF	in PPP	GDP in %	
Canada	1522.76	1678.12	3.80	
Euro Area	3471.46	4179.16	10.36	
Japan	6351.29	7370.47	18.55	
Sweden	815.55	761.78	1.63	
Switzerland	8754.38	6866.18	11.29	
UK	1492.73	1443.22	3.48	
USA	4275.43	4293.46	7.65	

Table 1: International holdings of total banknotes per capita and relative to GDP in 2015

*Note:* End-of-year values of banknotes in circulation, converted with end-2015 current exchange rates. PPP-calculation based on purchasing power parities computed by the OECD.

Table 2: Nominal	value of CH	F 1000	banknotes	held	for	hoarding	and	transaction	purposes
(CHF billion)									

	Total	Hoarding	Transactions
1956 - 1960	1.75	0.87	0.88
1961 – 1965	2.68	1.38	1.30
1966 – 1970	3.41	1.51	1.90
1971 – 1975	5.80	2.77	3.02
1976 – 1980	8.93	4.58	4.35
1981 – 1985	10.81	4.50	6.32
1986 – 1990	13.12	4.38	8.74
1991 – 1995	13.88	4.81	9.08
1996 - 2000	17.46	8.67	8.80
2001 - 2005	22.16	14.22	7.94
2006 - 2010	27.29	17.02	10.27
2011 - 2015	39.30	28.70	10.60

Notes: Numbers are based on the estimated hoarding shares and average nominal values of CHF 1000 banknotes in circulation in the respective time period.



Figure 1: Nominal value of total banknotes in circulation in Switzerland (left panel: in CHF billion, right panel: growth rate in percent)

Figure 2: Nominal value of total banknotes per capita in circulation (blue line, left logarithmic scale) and corresponding total banknotes (green line, right logarithmic scale) in Switzerland



Figure 3: Real value of total banknotes per capita in circulation (red line, right scale) and corresponding total banknotes (blue line, left scale) in Switzerland

#### TOTAL BANKNOTES IN CIRCULATION IN SWITZERLAND

CHF CHF billion 80 -9 0 0 0 70 8 0 0 0 60 7 0 0 0 50 6 0 0 0 40 5 0 0 0 30 4 0 0 0 20 3 000 10 2 0 0 0 0 1 000 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 00 05 10 15 Total (left axis) Per capita (right axis) Source: SNB

Real value, in prices of 2015, total and per capita

Figure 4: Ratio of value of total banknotes in circulation to nominal GDP / to nominal private consumption (blue line, left scale) and nominal interest rate (rate on savings deposits, red line, right scale) in Switzerland





Figure 5: Nominal value and corresponding share of different banknote denominations in circulation in Switzerland



Figure 6: The ratio of banknotes to nominal private consumption in Switzerland: denominational breakdown (left panel: large denominations, right panel: small denominations)



CHF 100

CHF 500

Source: SNB

RATIO OF VALUE OF BANKNOTE DENOMINATIONS TO NOM. PRIVATE CONSUMPTION IN SWITZERLAND



Figure 7: The ratio of banknotes to nominal GDP in Switzerland: denominational breakdown (left panel: large denominations, right panel: small denominations)



Figure 8: Seasonal pattern of CHF 1000 banknotes (left panel: seasonal factors as time series, right panel: seasonal factors of respective month over entire sample period)



Figure 9: Seasonal pattern of CHF 100 banknotes (panels: cf. Figure 8)





Figure 10: Seasonal pattern of CHF 50 banknotes (panels: cf. Figure 8)

Figure 11: Seasonal pattern of CHF 20 banknotes (panels: cf. Figure 8)



Figure 12: Seasonal factors of CHF 1000 banknotes (left panel: corrected for tax effects, right panel: original series)





Figure 13: Share of hoarding of CHF 1000 banknote using CHF 20 banknote as reference series

