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Stefan Gerlach, Hong Kong Institute for Monetary Research (HKIMR) and Hong Kong Monetary Authority (HKMA) and CEPR
Petra Gerlach-Kristen, Universität Basel

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Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Estimates of Real Economic Activity in Switzerland, 1885-1930*

This Paper uses annual data spanning 1870 to 1930 on a set of variables correlated with business conditions to construct an index of real economic activity in Switzerland. We extract an estimate of the common component of the data series using principal components analysis and the unobservable variables approach proposed by Stock and Watson (1989, 1991). The resulting index is similar to, but displays more variation over time than, that constructed by Andrist, Anderson and Williams (2000).

JEL Classification: E32, N13 and N14
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Stefan Gerlach
Executive Director (Research)
Hong Kong Monetary Authority (HKMA)
3 Garden Road, 30th floor
Central
Hong Kong
Tel: (85 2) 2878 8800
Fax: (85 2) 2878 8167
Email: stefan_gerlach@hkma.gov.hk

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Petra Gerlach-Kristen
WWZ
Universität Basel
Petersgraben 51
4003 Basel
Switzerland
Email: petra.kristen@unibas.ch

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1 Introduction

While macroeconomists have much to learn from the past, the poor availability of data is a major obstacle to empirical research on many episodes of historical interest. Although there frequently are good data available on easily observed variables, such as consumer prices, exchange rates and interest rates, data on variables that need to be constructed are, with the possible exception of monetary aggregates, difficult to come by. In particular, it is at times difficult to find measures of real economic activity, which plays a critical role in many macroeconomic events and analyses.

This paper is concerned with the question of real economic activity in Switzerland before 1929, when the official data on real GDP starts. It is motivated by the study by Gerlach-Kristen [7] which estimates money demand in Switzerland from 1936 to 1995. In that paper, the lack of income data makes an estimation of money demand before the 1930s impossible despite the fact that observations on money and interest rates are available prior to that date. This raises the question how estimates of activity before 1930 can be formed.

This study is related to the paper by Andrist, Anderson and Williams [1], AAW in the following, which contains estimates of real output in Switzerland in the period 1914 to 1947. The authors carefully consider possible indicator variables of real output and use qualitative judgment to construct an index of economic activity at an annual frequency. Between 1914 and 1922 the index is calculated as a three-year moving average of railroad transportation data, between 1925 and 1929 as a moving average of industrial production, and for 1923 and 1924 as a combination of the two series. For the period 1930 to 1947, the authors use data on real national income.

While the AAW estimates of business activity appear plausible, the paper has two shortcomings. First, the authors do not use any formal criteria to determine the choice of indicator time series, when to switch between them, and the degree to which they should be smoothed. Rather than letting the data decide what weight should be attached to the different time series, the authors do so on the basis of their views of the likely behavior of economic activity in the time period under consideration. Second, all estimates are inherently subject to uncertainty, and it generally desirable to characterize that uncertainty explicitly. The approach chosen by AAW renders that impossible. Overall, while their index appears plausible, the authors' informal technique makes it difficult to assess the information content of the constructed output series, which suggests that additional estimates of real activity are desirable.

In this paper we rely on formal statistical techniques to estimate two measures of an index of economic activity in Switzerland at an annual frequency for the period 1885 to 1930. Our framework lets the data speak as to what information they contain about real output. For instance, and to preview our results, we find that real trade flows are strongly related to movements in economic activity, but that telephone and postal receipts are not. Moreover, the statistical procedures allow us to compute confidence bands for real output growth. This indicates what we can, and can not, infer about cyclical fluctuations in the period studied.

The first measure of economic activity is obtained by applying principal components analysis to a set of time series which are likely to covary with economic activity. While this is a simple and, in our view, useful way to assess output movements, it is not possible to test hypotheses about the information content of individual indicator variables. In turn, this implies that the resulting output index might in part be based on variables that in fact contain little or no information about real activity. We therefore in a second step use the unobservable components time-series approach initially proposed by Stock and Watson [12] and [13], SW in the following, to estimate a coincident index. This approach has the benefit that it permits us to explore formally the information content of the indicator series and to assess the likely size of the estimation error, which is helpful for any subsequent econometric analysis of the data.

Before proceeding, we emphasize that while econometric techniques can be helpful when conducting research on macroeconomic events in the distant past, they are at most a complement to, but no substitute for, careful historical analysis. Despite this, we hope that our estimates will prove useful to those interested in macroeconomic fluctuations in Switzerland before 1930.

The rest of the paper is organized as follows. In Section 2, we provide a narrative overview of Swiss economic history during the period under consideration. In Section 3, we review a number of time series that are likely to contain information about real output in Switzerland. Since the starting dates for these series vary, we consider several sets of indicator series that span different periods. We start by considering data sets that contain the few time series that are available for relatively long periods, before turning to data sets that contain an increasingly larger number of time series, which however only are available for shorter periods. We apply principal components analysis to the data and use the first component as a measure of economic activity. Comparing the correlations between the different indices, we find that those computed on data starting before 1885 are not strongly correlated with the indices which include time series commencing later. By contrast, the index computed with the five data series available from 1885 onwards is strongly correlated with indices constructed with later data sets. Thus, there seem to be good reasons to "wait" with constructing the index of economic activity until 1885, while little appear to be gained from using a broader range of data that become available later. We therefore focus on the 1885 to 1930 period.

In Section 4, we apply the unobserved components approach suggested by SW to extract a measure of real output from the 1885 data set. We find that of the five variables used for the principal components index, only three appear to contain information about the state of the business cycle. In passing, it is worth noting that the indices of coincident indicators computed by SW for some thirty years of quarterly US data are based only on four indicator time series.[1] Thus, our finding that a few time series are sufficient to assess economic activity in Switzerland is not surprising. Dropping the uninformative variables, we use a two-sided smoother to provide an output estimate from 1885 to 1930 and to compute the standard error for this variable.[2] We then compare our two different measures of activity, which are highly correlated, and discuss how they differ from the index proposed by AAW. Section 5 provides our conclusions. The Appendix presents details of the statistical methodology and an estimate of the level of real output for the years 1885 to 1930.

2 Economic Activity in Switzerland, 1870 to 1930

The aim of this section is to briefly review developments in economic activity in Switzerland over the period 1870 to 1930, which provides us with a reference point for the interpretation of the econometric estimates below. The discussion draws heavily on Bergier [2], Böhi [3] and David [5], to which the interested reader is referred.

The Swiss economy experienced robust growth over the 1870s and 80s, which was to a large extent due to an upswing in Germany. These "Grunderjahre" in turn had taken their origin at least in part from French reparation payments after the war of 1870/71. Switzerland during these decades saw an increase in exports of machines, watches and food and witnessed large investments in housing as well as in the new railway network and steam power plants. Agriculture, which traditionally had been the most important sector of the Swiss economy,

[1] Note also that SW use the same four series as the Department of Commerce does to constuct its index of coincident economic indicators.

[2] A two-sided smoother makes use of the information available over the entire sample period, while a one-sided smoother constructs an estimate of the unobserved variable at time t using information only up to t. See Hamilton [8], pp. 394-397.

came under pressure from competition mainly by Latin American countries which had recently entered world markets. As a consequence, Swiss exports temporarily declined in the first half of the 1890s, but they recovered after 1895, when economic activity picked up worldwide. This global boom was accompanied by rising prices of primary products, especially metals. By 1900, however, these prices had collapsed, and investment and employment in Switzerland declined.

In 1904, there was a short upswing of the business cycle which was mainly due to increased investment in railways and power plants, a development which was associated with a considerable loan growth. In the following years, the Swiss economy was to a large extent driven by expectations of an imminent war. Europe was busily building up arsenals, and in Switzerland, infrastructure investments once again boomed. In 1912/13 the fear of a conflict caused liquidity shortages in the financial sector and led to the bankruptcy of a number of smaller banks. The outbreak of the war, in which Switzerland was neutral, brought for the country a period of increased exports of military equipment and luxury goods. Yet soon, the parties at war introduced foreign exchange control in order to ensure the purchase of goods vital for the armed forces, and the falling demand for Swiss luxury goods triggered the decline of the textile sector. At the same time, the drying-up of international markets made it difficult to obtain imports, and the Swiss government adopted price controls and rationing. Moreover, since the importation of coal from Germany had all but ceased, the switch from steam to water power plants became inevitable.

After the war, Switzerland imported a large number of machines and continued electrification programs. At the same time, the former belligerent powers imported Swiss consumption goods. The recovery faltered when, from 1920 onwards, the currencies of Austria, France, Germany and Italy began to depreciate, leading to a sharp deterioration of Switzerland's competitiveness. As a reaction, the government introduced trade restrictions and labor market measures to maintain employment. After the stabilization of the mark, Swiss employment rose, the food, machine and chemical industries flourished and by 1928/29, full employment was reached. However, trade restrictions dominated the international markets, and Switzerland tightened its controls further after Black Thursday on October 24, 1929. The crisis hit the country with full force in 1931.

3 Data

There is only a limited number of time series available which can be used to model Swiss economic activity before the 1930s. We consider twelve series which we group in seven data sets. The first set starts in 1870 and comprises *post receipts* and *telegraph and phone receipts*. While these time series are in nominal terms, it is difficult to deflate them due to the absence of a good price index. Mail and telecommunication prices were administratively set and were probably not closely linked to the level of consumer prices. Indeed, it seems likely that post and communication prices declined sharply in real terms. As we discuss further below, the fact that we do not deflate these variables introduces a measurement error. The second data set contains the same time series as the first, but also includes *railway freight* and *passenger* numbers, which are available from 1880 onwards.[3] Adding *export* and *import* data, for which data have been reported since 1885, we obtain the third data set. We deflate these trade series by the wholesale price index. The fourth group covers data on the number of *stock companies*, which are accessible from 1902 onwards. The fifth data set starts in 1906 and includes alternative measures of *railway freight* and *passengers*.[4] To this, the sixth set adds *giro transfers*, records for which are available following the establishment of the Swiss National Bank in 1907 onwards. We deflate the *giro* records by the consumer price index. The seventh data set, finally, contains the time series of the earlier data sets plus the number of *bankruptcies* and *forbearances* and starts in 1917.[5] For simplicity, below we refer to the different data sets by year in which they start.

Table 4 summarizes the availability of the time series and shows the test statistics of Phillips-Perron unit root tests. We perform this test since the data series grow over time and are likely to be non-stationary. We do not reject the hypothesis of a unit root in the logarithm of any of the indicator series. The growth rates of our series appear stationary, with the exception of stock *companies*, *bankruptcies* and *forbearances*. We attribute the failure of the Phillips-Perron test to reject the hypothesis of non-stationarity to the low power of unit root tests in small samples and perform the econometric analysis on the once-differenced data of all series. Thus, all references below are to the growth rates of the different variables.

The data are taken from four sources. The series on *bankruptcies*, *forbearances*, *giro transfers*, *post receipts*, *telegraph and phone receipts* and *stock companies* stem from the Eidgenössisches Statistisches Amt [6], the *railway* and *trade* data from Mitchell [10], the wholesale price index from Ritzmann-Blickenstorfer [11] and the consumer price index from Bordo and Jonung.[6]

[3] *Railway freight* is measured in units of million metric tons of traffic; *railway passengers* by millions of passengers.

[4] The alternative data on *railway freight* is measured in units of million ton-kilometers; *railway passengers* by millions of passenger kilometers.

[5] "Nachlassstundungen" in the German sources.

[6] The Bordo-Jonung data base is described in Bergman, Bordo and Jonung [4].

Table 1: Data

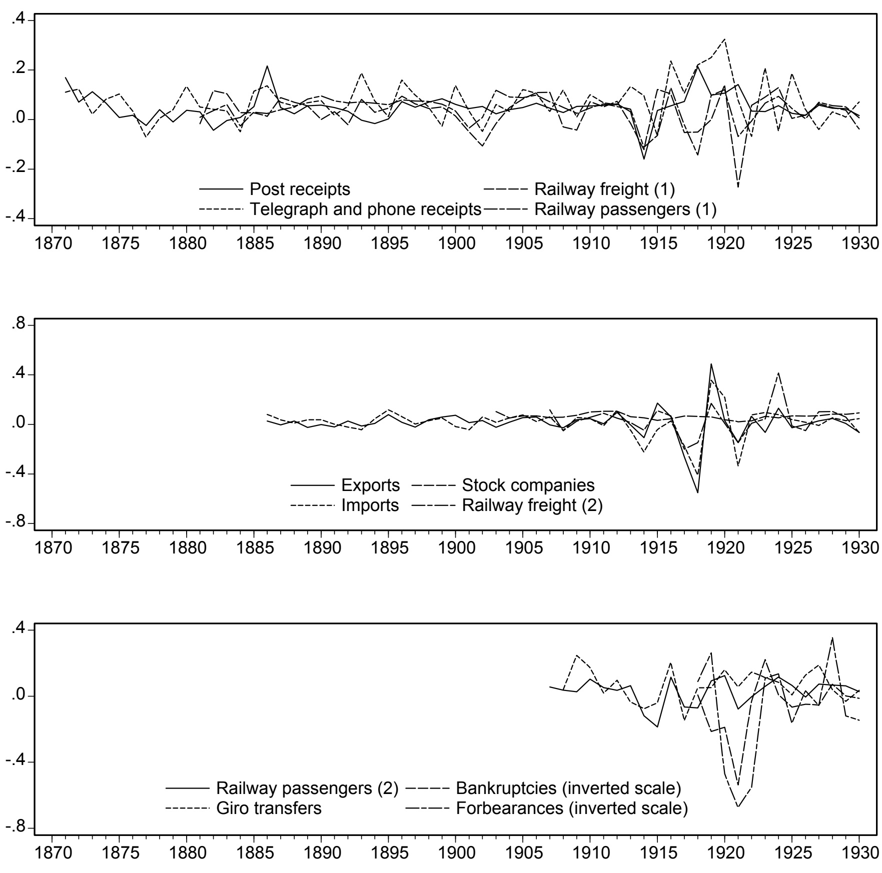
Name of series	Starting date of level data	Unit root test (level) [critical value]	Unit root test (change) [critical value]
Post receipts	1870	-2.246 [-3.485]	-5.846** [-3.486]
Telegraph and phone receipts	1870	-1.670 [-3.485]	-7.321** [-3.486]
Railway freight (1)	1880	-2.697 [-3.500]	-7.245** [-3.502]
Railway passengers (1)	1880	-1.093 [-3.500]	-5.804** [-3.502]
Export	1885	-3.041 [-3.511]	-9.263** [-3.514]
Import	1885	-2.346 [-3.511]	-7.325** [-3.514]
Stock companies	1902	-1.873 [-3.580]	-2.649 [-3.587]
Railway freight (2)	1906	-2.014 [-3.612]	-4.693** [-3.622]
Railway passengers (2)	1906	-1.486 [-3.612]	-4.276* [-3.622]
Giro transfers	1907	-1.956 [-3.622]	-4.340* [-3.633]
Bankruptcies	1917	-1.100 [-3.829]	-2.985 [-3.873]
Forbearances	1917	-1.213 [-3.829]	-2.274 [-3.873]

Note: The series *stock companies* is computed from the three time series "existing stock companies", "new stock companies" and "failed stock companies". *Exports* and *imports* are deflated by the whole price index, *giro transfers* by the consumer price index. For the unit root tests, we use Phillips-Perron tests including a trend, an intercept and a truncation lag of three and compute the statistics for the available sample periods. */** denotes significance at the five / one percent level. Critical five percent values in brackets [].

4 Principal Components Analysis

To obtain an impression of economic activity in Switzerland between 1870 and 1930, consider Figure 1, which shows the growth rates of the indicator variables. The time series display close correlations and are most volatile around the First World War. Growth rates turn negative as early as 1913, recover in 1915 and decline again after the end of the war. The fact that the series in the figure appear to move together suggests that they are all driven by the same underlying factor, which we may think of as aggregate economic activity. The purpose of our econometric estimates is to extract this common component from the data. In this section, we apply principal components (PC) analysis to do so.

Figure 1: Growth rates of indicator series



Before proceeding, it should be noted that real *export* and *import* growth rates are tightly correlated ($\rho = 0.8$). Since the series contain essentially the same information, we rely in the analysis below on a single variable, *trade*, which is defined as the growth rate of the sum of real *imports* and *exports*. For the same reason, we omit the second measure of *railway passengers* from the estimations since its correlation with the first measure is about 0.9.

Table 2 shows the results of the PC analysis of the seven data sets. The procedure decomposes the n time series of each set into n orthogonal factors, where the first of these factors is the linear combination of series which explains the largest fraction of their variances.[7] To understand the table, consider the first column, in which we report the PC statistics for the 1870 data set, which consists of *postal receipts* and *telegraph and phone receipts*.[8] The first line indicates that the first PC explains about 64% of the variance of the two series (implying that the second PC explains the remaining 36%). The factor loadings suggest that the series play a roughly equal role in the composition of the first PC.

Next consider the second column, in which we compute the first PC on the 1880 set, which is made up by the two series in the first group and *railway freight* and *passengers*. Since the latter time series become available ten years after the data series in the first group, we can compute the first PC only starting in 1880. We find that the first PC accounts for 40% of the variance of the four series (implying that the second to fourth PCs account for the remaining 60%). The fact that the factor loadings on the *railway freight* and *passengers* are much larger than those on the growth of *postal* and *telegraph and phone receipts* suggests that the two sets of series are not strongly correlated. This in turn indicates that only one of these pairs of series is correlated with aggregate economic growth.

The rest of the table shows the fraction of variance explained by the first PCs for the other data sets, together with the factor loadings. While from the 1880 set onwards, the first PC captures around forty percent of the variances, the factor loadings shift between the different data sets. In particular, the factor loadings of *post* and *telegraph receipts* growth decrease and even turn negative. This suggests that these two variables might not be informative about output growth. When the broadest data set, which starts in 1917, is used, the factor loadings are largest for *trade*, *railway freight* and *passengers*. Since these data are already available in the 1885 set, this finding suggests that it might be possible to construct a good measure of economic growth starting in the late nineteenth century.

[7]For a discussion of the PC analysis, see, e.g., Johnston [9].

[8]Since we perform the analysis on growth rates, the first data point of the PC analysis corresponds to the year 1871. However, since an index of the level of economic activity based on these series can be computed starting in 1870, in what follows we refer to all data sets by the year in which their level figures are first available.

Table 2: PC analysis

Data set	1870	1880	1885	1902	1906	1907	1917
Fraction of variance explained by first PC	0.643	0.404	0.439	0.387	0.425	0.396	0.403
Factor loadings (normalized)							
Post receipts	0.500	0.012	-0.038	-0.043	-0.040	-0.014	-0.165
Telegraph and phone receipts	0.500	0.154	0.039	0.013	-0.028	-0.011	-0.045
Railway freight (1)	-	0.407	0.317	0.292	0.242	0.202	0.202
Railway passengers	-	0.427	0.350	0.321	0.253	0.217	0.198
Trade	-	-	0.332	0.309	0.256	0.214	0.176
Stock companies	-	-	-	0.108	0.067	0.056	0.118
Railway freight (2)	-	-	-	-	0.251	0.205	0.187
Giro transfers	-	-	-	-	-	0.130	0.027
Bankruptcies (inverted)	-	-	-	-	-	-	0.158
Forbearances (inverted)	-	-	-	-	-	-	0.144

Table 3: Correlations of first PCs

	1870	1880	1885	1902	1906	1907
1880	0.221					
1885	0.005	0.932				
1902	-0.046	0.929	0.991			
1906	-0.144	0.877	0.968	0.973		
1907	-0.060	0.891	0.966	0.966	0.986	
1917	-0.453	0.828	0.879	0.918	0.936	0.920

Note: The sample periods vary depending on data availability.

In Table 3 we show the pairwise correlations of the first PCs of the seven data sets. To understand the table, consider the correlation of the first PC for the 1870 data set with the first PC of the 1880 set. The fact that the correlation is 0.2 indicates that these data contain very different information, as already noted. The correlations of the first PC of the 1870 set with those of later data groups are even smaller and frequently negative. This finding might be due to the fact that, as mentioned above, lacking an appropriate price index, we have not deflated the *post* and *telegraph receipts*. Overall these results suggests that it is not sensible to compute a measure of real economic activity on the basis of the data available from 1870 onwards.

Consider next the correlations of the first PC of the 1880 set with those of later data sets and note that these are much higher, typically about 0.8 to 0.9. Including the *railway* data in the analysis thus appears to add substantially to the information contained in the *post* and *telegraph* series. The correlations of the first PC of the 1885 data set are even larger, and this set seems to capture the underlying information on economic activity nearly as well as later first PCs. We therefore use the 1885 PC as a first measure of the index of real economic activity in Switzerland.

We call the PC measure of real output growth the PC index. This index is constructed as a weighted average of the growth rates *post* and *telegraph receipts*, *railway freight*, *railway passengers* and *trade*, where the respective weights are given in the third column in Table 2 as -3.8, 3.9, 31.7, 35.0 and 33.2 percent. For reference, it should be noted that a Q-test does not reject the hypothesis of no serial correlation in the common component. The PC index is presented in Figure 3 together the unobserved components (UC) index, which we discuss next.

5 Unobserved Components Analysis

The PC measure of real economic activity developed above has two shortcomings. First, we cannot test whether the five indicator series used in the construction of the index in fact are informative, that is, whether their factor loadings should indeed be non-zero. Given that the factor loadings on *post* and *telegraph receipts* are small, these series do not appear to reveal much information about the state of the business cycle. Second, we cannot assess the precision with which we have estimated movements in economic activity. We therefore now turn to the unobserved components model, proposed by SW, which is not subject to these shortcomings.

5.1 Estimation of the UC index

The SW model starts from the assumption that the researcher observes a vector X_t which contains variables correlated with the level of economic activity. In our case, X_t is a 5×1 vector containing the five level series available from 1885 onwards. The model assumes that these series are linearly related to the unobserved level of real output, C_t, which is a scalar. Formally, we have that

$$X_t = \beta t + \gamma_X C_t + v_t, \qquad (1)$$

where β is a 5×1 vector, t is a time trend, v_t a 5×1 vector containing unobserved disturbances, and where the 5×1 vector γ_X reflects the impact of economic activity on the indicator series. We assume that the covariance matrix of v_t is diagonal, that is, that the disturbances of X_t are uncorrelated. Note that since the elements of β may differ, the indicator series can have different average growth rates. Moreover, the v_t vector can be interpreted as allowing for (potentially non-stationary) measurement errors, which could arise from many factors, including the fact that some time series are not deflated. Defining $Y_t \equiv \Delta X_t$, we can rewrite equation (1) as

$$Y_t = \beta + \gamma_X \Delta C_t + \Delta v_t, \qquad (2)$$

where we assume that the elements of Δv_t are normally distributed and serially uncorrelated. Equation (2) thus states that the growth rate of each indicator series is given by a constant, the growth rate of the economy and a shock.

The SW model supposes that ΔC_t obeys an autoregressive process. In light of this and despite the finding that the PC index of economic activity displays no serial correlation, we assume in a first step that ΔC_t follows an AR(1) process, so that

$$\Delta C_t = \delta + \phi \Delta C_{t-1} + e_t, \qquad (3)$$

where δ is the mean growth rate of real output and e_t a white noise disturbance. It should be noted that the observation equation (2) and the transition equation (3) constitute a state-space system. The indicator series we used in the construction of the PC index take the role of signals, while economic growth is the state variable.

Hamilton [8] shows that if the disturbances in such a system are normally distributed, which we have assumed, it can be estimated using Kalman filtering. We make the identifying assumption that the variance of the state variable, σ_e^2, is equal to unity. Column (1) in Table 4

Table 4: Kalman filter estimates

Equations (2) and (3) Sample period 1886-1930			
Model:	(1)	(2)	(3)
Number of indicator series:	5	5	3
ϕ	0.119	-	-
	(0.172)		
γ_{Post}	-0.030	-0.052	-
	(0.116)	(0.105)	
γ_{Tel}	0.135	0.115	-
	(0.200)	(0.214)	
$\gamma_{Freight}$	0.646**	0.669**	0.680**
	(0.227)	(0.180)	(0.082)
γ_{Pass}	0.945**	0.905**	0.886**
	(0.123)	(0.082)	(0.051)
γ_{Trade}	0.717**	0.746**	0.768**
	(0.122)	(0.113)	(0.066)
Log likelihood	-292.32	-292.53	-165.67

Note: Maximum likelihood estimates. ** denotes significance at the 1 percent level. Standard errors in parentheses.

presents the estimates of ϕ and γ_X using the five signal series of the 1885 set (standard errors in parentheses).

Since we do not reject the hypothesis that ϕ equals zero, the empirical results suggest that ΔC_t is a white noise process, implying that real output follows a random walk with drift. We therefore reestimate the system under this assumption and report the results in column (2).[9] Since γ_{Post} and γ_{Tel} are insignificant, we drop the *post* and *telegraph receipts* as signals and obtain the results in column (3).[10]

Appendix A.1 shows that the SW methodology allows us to calculate economic growth as a weighted average of the signal series. The weights for the growth rates of *railway freight*, *passengers* and *trade* are given by a 3×1 vector G which is provided in Table 5. We also present δ, the average growth rate of the UC index over the period 1885 to 1930, which is estimated as about 3.7 percent.

Table 5: Weighting vector for signal series and average growth rate of economic activity

$G_{Freight}$	16.054
G_{Pass}	68.911
G_{Trade}	15.034
δ	3.661

Note: Values in percent.

We show the UC index in Figure 3 together with the PC index. Since the Kalman filter also provides us with an estimate of the standard error, we include the 95 percent confidence band as a measure of the precision with which real output growth is estimated. Before turning to the interpretation of our estimates of Swiss economic growth from 1885 to 1930, it is worth noting that with the exception of 1915 and 1921, the PC index lies within this confidence band. The PC index thus seems to capture the business cycle almost as well as the UC index.

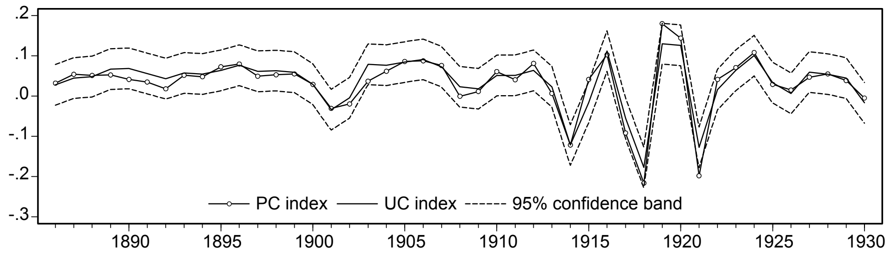
5.2 Historical Interpretation

How do the PC and UC indices relate to the historical evidence on economic growth in Switzerland from 1885 to 1930? Figure 3 shows that before the turn of the century, growth was positive

[9] A likelihood ratio test does not reject the restriction $\phi = 0$.

[10] Note that since we use a smaller number of signal series, it is not possible to compare this model with those presented in the first two columns.

Figure 2: PC and UC index



and quite smooth.[11] There is a small reduction in the expansion rate at the beginning of the 1890s, which coincides with the narrative evidence in Böhi [3] on falling exports. The slump in activity in 1901 is most likely due to the collapse in primary goods prices and the consequent investment crisis, while the decline in growth in 1908/09 could reflect the worldwide financial crisis. In 1914, Swiss economic activity contracted sharply, which may be attributed to the onset of World War I. In the following years, neutral Switzerland saw high growth rates as economic activity recovered to levels similar (but below) those of before the war.[12] The PC and UC indices show furthermore that the last year of the war brought a collapse in growth which most likely resulted from decreased external demand. In 1919 output rebounded due to an expansion of trade associated with the end of hostilities. The estimates suggest that the Swiss economy experienced a recession in 1921, which probably was caused by a weakness of global economic conditions, the erosion of the currencies of Switzerland's neighboring countries and the resulting loss of competitiveness. Following the stabilization of the mark at the end of 1923, economic activity in Switzerland recovered for a number of years, but output growth again hit zero in 1930, the year which for Switzerland marked the onset of the Depression. In sum, the activity indices resulting from the PC and UC analysis appear to reflect the historical evidence on business fluctuations quite well.

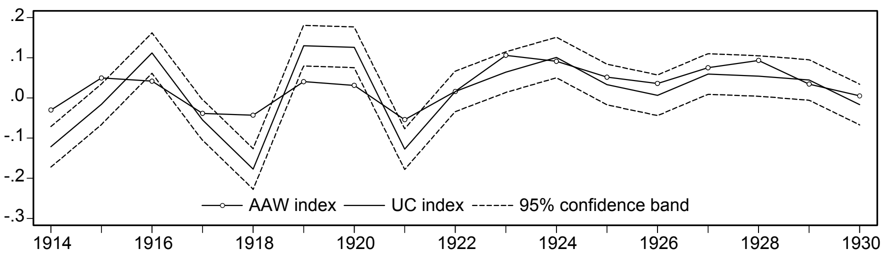
[11] In the interpretation of these graphs, it should be recalled that the two indices are unit-free (since they have been estimated on normalized data).

[12] This effect is clearly seen in the level estimates of economic activity in Table 6 in Section A.2.

5.3 Comparison with AAW

We end this section by comparing our UC index with the measure of real economic activity constructed by AAW. Of course, since both indices are estimates, this comparison is on its own unlikely to provide a firm reason to prefer either of them. Figure 3 shows that for the period 1914 to 1930 in which they both are available, the two indices follow a similar time path. Moreover, they are also strongly correlated ($\rho = 0.8$). It therefore seems clear that they capture much the same information. However, in the 17 year period considered, the AAW index lies outside the confidence band for the UC index 4 times, and shows less variability than the UC index. This suggests that the practise of AAW to use a three-year moving average leads to a potentially too smooth index of economic activity (although the higher volatility of the UC index could also reflect an inappropriate choice of indicator series). However, since AAW do not employ any formal techniques to assess goodness-of-fit, all we can say is that their estimates of real output match poorly with those resulting from the econometric methods we apply.

Figure 3: AAW index and UC confidence band



6 Conclusions

In this paper we use principal and unobserved components methods to construct a "missing" historical data series. The two estimates of real economic activity in Switzerland over the period 1885 to 1930 are quite similar and seem to reflect historical events well. We find a first clear downturn in 1901 and recessions in 1914, 1918 and 1921. Moreover, the two indices resemble that by AAW, but are more variable. One interesting finding of practical econometric interest is that the principal components index is very similar to the index computed using unobserved components. In general, the latter method is better able to capture any dynamics in the underlying factors. However, in this specific case there appears to be little time series structure to the common factor and the principal components index therefore performs quite well. It would be interesting to see whether the two methods would give similar estimates also for other time periods. We end by reiterating that any careful analysis of economic activity in Switzerland in the period studied here should relay on better historical judgment than we can offer. Despite this, we hope that the analysis presented in this paper will spark more research on this interesting epoch.

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A Appendix

A.1 Deriving the UC index

Since ΔC_t follows a random walk, equation (3) is reduced to

$$\Delta C_t = \delta + e_t. \tag{4}$$

Inserting equation (4) in equation (2), we get

$$Y_t = \beta + \gamma_X(\delta + e_t) + \Delta v_t. \tag{5}$$

Note that the average growth rate of indicator series i equals $\mu_i = \beta_i + \gamma_{iX}\delta$. Next, define the variance of series i as σ_i^2. We denote $\widehat{Y}_{it} = (Y_{it} - \mu_i)/\sigma_i^2$, $\gamma_i = \gamma_{iX}/\sigma_i^2$ and $u_{it} = \Delta v_t/\sigma_i^2$ and normalize equation (5) to yield

$$\widehat{Y}_{it} = \gamma e_t + u_t, \tag{6}$$

where γ contains the single γ_is and u_t the u_{it}s. We call the variance of u_{it} σ_{ui}^2. Since we identify the unobserved variable by assuming that its innovation has a unit variance, the variance of the two sides of equation (6) equals for each element

$$1 = \gamma_i^2 + \sigma_{ui}^2.$$

Thus, $\gamma_i = \sqrt{1 - \sigma_{ui}^2}$, so that for n signal series, we need to fit only n, not $2n$, parameters in the subsequent maximum likelihood estimation.

SW show that the best estimate of economic growth is

$$\Delta C_{t,t} = G\widehat{Y}_t, \tag{7}$$

where G determines the weight of the signal series in the construction of the UC index. The individual elements of G are given by

$$G_i = \frac{g_i/\sigma_i^2}{\sum_{j=1}^{n} g_j/\sigma_j^2},$$

where the scalar g_i is the ith element of

$$g = \gamma[\gamma\gamma' + \Sigma_u]^{-1},$$

with Σ_u denoting the covariance matrix of the errors in equation (6). Noting that $Y_{it} = \widehat{Y}_{it}\sigma_i^2 + \mu_i$, replacing in equation (7) and inserting equation (4), we get that

$$\Delta C_{t,t} = \delta + e_t = G\mu + GY_\sigma,$$

and

$$\delta = G\mu,$$

where element i of Y_σ equals $\widehat{Y}_{it}\sigma_i^2$.

A.2 Level estimate of economic activity

While growth data are required for a large number of applications in economic history, the assessment of the level of real output is of more general interest. We therefore provide our estimates of the level of economic activity in Switzerland for the period 1885 to 1930. SW show that real activity can be calculated as

$$C_t = \exp \sum_{s=1}^{t} \Delta C_s,$$

where we set C_{1885} equal to 100. Table 6 below shows the estimates derived from the UC index.

Table 6: Economic activity (level data)

1885	100.00	1895	170.06	1905	277.78	1915	358.85	1925	447.89
1886	102.82	1896	183.57	1906	304.25	1916	401.25	1926	450.79
1887	107.51	1897	195.15	1907	327.14	1917	379.83	1927	478.52
1888	112.84	1898	207.84	1908	334.80	1918	318.15	1928	505.27
1889	120.66	1899	220.49	1909	340.92	1919	362.31	1929	528.28
1890	129.24	1900	227.02	1910	358.76	1920	410.84	1930	519.50
1891	136.66	1901	219.44	1911	377.63	1921	361.66		
1892	142.66	1902	218.53	1912	402.49	1922	367.53		
1893	151.07	1903	236.50	1913	411.78	1923	391.79		
1894	159.55	1904	255.28	1914	364.55	1924	433.24		