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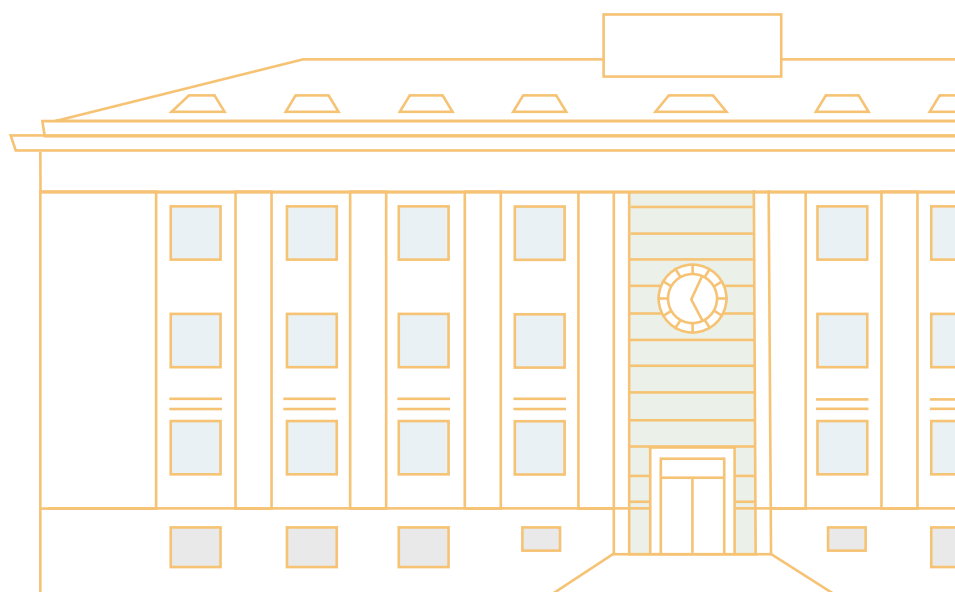
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# 160 Years of Aggregate Supply and Demand in Switzerland

**Rebecca Stuart**

# **160 YEARS OF AGGREGATE SUPPLY AND DEMAND IN SWITZERLAND**

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## **Abstract**

This paper studies the causes of movements in inflation and output in Switzerland over 160 years between 1855 and 2015. Aggregate supply and demand shocks are identified in a structural VAR and their evolution and effect on prices and output is discussed. Shocks to the Swiss economy have generally, although not uniformly, declined in magnitude over the sample period. The pre-Gold Standard era and the inter-war period were particularly volatile. Surprisingly, the global financial crisis represented a much smaller shock than either of the World Wars, the deflation of the 1920s, or the Great Depression.

Keywords: Switzerland, aggregate supply and demand, long time series, SVAR.

JEL Number: E1, E4, N1

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## 1. Introduction

Understanding the evolution of the economy in past historical episodes is a central task for economic historians. While a complete analysis requires an assessment of a wide range of economic phenomena, in this paper I take a small step in this direction by providing an econometric study of Swiss business cycles over the 160 year period between 1855 and 2015. My analysis focuses on the relative importance of disturbances to the economy's supply capacity versus shifts in the demand for goods and services in accounting for cyclical swings. Previous studies have discussed the development of the Swiss economy over this time period, while others have considered econometrically those forces acting on the economy over shorter samples.<sup>1</sup> However, I am not aware of a study that provides econometric estimates of the shocks impacting on the Swiss economy over such a long time period.

Since few data series are available for such an extended sample period, I focus on output and prices. Using annual data on GDP and consumer prices, I estimate the aggregate supply and demand shocks which affected the Swiss economy in a structural VAR framework. The shocks are identified using an intuitive identification strategy, suggested by Ball, Mankiw and Romer (1988) and employed in Stuart (2019), that assumes that the price elasticity of aggregate demand is (minus) unity. The estimated shocks are discussed in detail and a historical decomposition of their effects on GDP growth and inflation is provided.

The long sample period covers several important episodes in Swiss economic history. The sample, which begins in 1855, includes the joining of the gold standard in 1878, the First World War, the deflation in the 1920s and the Great Depression. The Second World War is followed by the so-called 'golden age' of economic growth in Europe and the Bretton Woods period. The break-up of

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<sup>1</sup> For instance, Baltensperger and Kugler (2016), Kugler and Sheldon (2010), Baltensperger and Jordan (1998), Gerlach (2016), Gerlach and Jordan (2012), Bernholz (2007) and Rich (2003).

Bretton Woods and the oil crises of the 1970s are followed by the Great Moderation, and subsequently the global financial crisis of the late 2000s. As a result, within the structural VAR framework, I am able to answer a number of questions which have not previously been addressed.

First, I show that plausible aggregate demand and supply shocks can be estimated for the entire sample period. Specifically, the shocks that I estimate clearly capture the key episodes in the sample period. These shocks indicate that aggregate supply shocks have overall had a larger impact on economic activity than aggregate demand shocks.

Second, the paper discusses how the size and variance of shocks that have hit the economy have changed over the course of the sample period. In particular, I show that aggregate supply shocks were particularly large in the pre-Gold Standard era. While the Gold Standard brought with it a period of stability, the First World War and interwar period are marked by large aggregate supply and demand shocks. In contrast, the more recent period, including the period of the global financial crisis, is characterized by much smaller shocks. Interestingly, the analysis shows that the effects of the global financial crisis on the Swiss economy were much smaller than that of the First and Second World Wars, the deflation in the 1920s and the Great Depression.

Third, the historical decomposition indicates which shocks were important drivers of GDP and inflation at different points in the cycle. While aggregate supply shocks drove much of the movements in GDP and inflation in the early part of the sample, aggregate demand shocks drove prices lower during the Great Depression. The period of the 1960s and early 1970s are characterized by rising prices due to aggregate demand shocks, whereas the recent low inflation environment is largely due to negative demand shocks. GDP growth was similarly strongly influenced by aggregate demand shocks in the pre-Gold Standard era. Negative aggregate supply shocks play an important role in holding

back GDP growth during the two World Wars, although this is offset by strong demand shocks. Much of the 1950s and 1960s are characterized by positive aggregate supply shocks, but the opposite is true after the first oil crisis in 1973. The growth in GDP after the global financial crisis has been affected by contractionary supply and demand shocks.

The paper is structured as follows. The next section describes the historical background, while the data are described in Section 3. The model specification, including the identification scheme, is discussed in Section 4. Section 5 discusses the results of the SVAR analysis, and a historical decomposition of the impact of the supply and demand shocks on inflation and output in Switzerland over the sample period. Section 6 provides a number of robustness checks and Section 7 concludes.

## **2. Historical background**

To put the discussion below in context, I start by providing the historical background. Figure 1 shows real GDP and CPI in log levels. The data are taken from Gerlach (2016), who constructed them by splicing data series from the website *Historical Statistics of Switzerland Online*. From Figure 1, prices did not increase much over the first half-century of the sample which begins in 1855. During this time, Switzerland became part of the Latin monetary Union, which was led by France, in 1865 (Baltensperger and Kugler (2016, p. 29). However, this was a bimetallic union that did not provide much stability. Prices remained quite volatile until France – and therefore Switzerland – joined the gold standard in 1878.<sup>2</sup> Nonetheless, the economy grew strongly during this time, and has been referred to as ‘*a prime example of a highly open economy*’ (Bordo and James (2007, p. 30). The establishment to the Swiss National Bank in 1907 served to strengthen the commitment to the gold standard and prices remained steady at close to the level

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<sup>2</sup> See Bordo and Kydland (1995), particularly Table 1, p. 434, for a discussion.

in the 1850s until the outbreak of the First World War. Prices more than doubled during the First World War (Bordo and James (2007) (Figure 1).<sup>3</sup> Nominal wages also increased, but by less, with the effect that their purchasing power declined. Army mobilization, and other costs associated with the war, led to rising public debt. The effect was that real GDP declined during the war, with the result an increase in social unrest, culminating in a nationwide strike in 1918.<sup>4</sup>

The end of the War is marked by an abrupt reversal in consumer prices. Like the rest of Europe, Switzerland had suspended gold convertibility during the war. In its aftermath, the SNB aimed to re-establish pre-War gold parity, which was achieved in 1925<sup>5</sup>, after a period of deflation and unemployment.<sup>6</sup>

The stability provided by the reestablishment of the gold standard was short lived, however, as the US stock market crash of 1929 marked the beginning of the great Depression. Prices declined markedly. Having recovered somewhat after the War, real GDP also declined again (Figure 1). Swiss industrial production fell 21% from 1929 to 1932.<sup>7</sup> However, Switzerland was one of the last countries to devalue its currency, waiting until 1936, and only after this did the Swiss economy begin to properly recover.<sup>8</sup>

Prices began to rise again at the start of the Second World War, exacerbated by large gold inflows. The gold inflows proved controversial in the post-War era, playing a role in Switzerland's initial economic isolation. Only a series of negotiated agreements with the Allied powers brought an end to this, and enabled

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<sup>3</sup> This was in line with the experiences of Switzerland's trading partners, and also other small neutral European countries at this time. See Gerlach, Lydon and Stuart (2015) for a discussion.

<sup>4</sup> Baltensperger and Kugler (2016, p. 59).

<sup>5</sup> Although it was only with the National Bank Act of 1929 that the legal basis for this was established (Bordo and James (2007, p. 48).

<sup>6</sup> Baltensperger and Kugler (2016) report that unemployment rose from 3,500 registered workers seeking employment in 1920 to approximately 100,000 in 1922. The hyperinflation in Germany during this time also had a large negative effect on Swiss exporters.

<sup>7</sup> See Zurlinden (2003) for a discussion of the impact of the Great Depression on Switzerland.

<sup>8</sup> Bordo and James (2007) note that France, the Netherlands and Switzerland stayed on the gold standard longer than any other European country.

exports and GDP growth to resume an upward trajectory in the post-War period (Bernholz (2007)). During this time, the Bretton Woods system was in place, the Swiss exchange rate was fixed, and the authorities had little control over domestic inflation.<sup>9</sup> Indeed, the Bretton Woods system relied on conservative US monetary and fiscal policy to ensure price stability. In the 1960s, the US commitment began to waiver and Switzerland, which was experiencing strong economic growth<sup>10</sup>, began to experience large capital inflows and imported inflation.

The breakdown of the Bretton Woods system following the suspension of gold convertibility by the US in 1971 created a conundrum for the SNB (Bernholz (2007)). Having fought capital inflows for a number of years, and with financial markets in turmoil, the SNB decided to float the Swiss Franc in 1973 and adopted a policy of targeting M1 money growth in 1974.<sup>11</sup> The result was that GDP slowed markedly (also impacted by the first oil crisis) (Figure 1), while inflation also slowed, albeit with a lag (Baltensperger and Kugler (2016, p. 70)).

The SNB's success in controlling inflation enhanced its credibility.<sup>12</sup> With a brief interlude between 1978 and 1980<sup>13</sup>, it continued this policy throughout the 1980s and 1990s. However, external shocks, particularly in the form of the wider global slowdown accentuated by the US stock market crash of October 1987, the fallout from the reunification of Germany and severe tensions in the EMS in the early

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<sup>9</sup> Although not formally a member of the Bretton Woods institutions, Switzerland effectively participated in the system from 1945 since the currency was fixed to gold. See Baltensperger and Kugler (2016, p. 93).

<sup>10</sup> Indeed, Nelson (2007) reports that Switzerland was almost the only country in the OECD to report a positive output gap in 1972, and that it had been positive since at least 1969.

<sup>11</sup> Although using monetary targets from 1974, the SNB only publicly announced a target in 1975. See Baltensperger and Kugler (2016).

<sup>12</sup> Nelson (2007, p. 718) reports a senior SNB official as stating that adoption of monetary targets showed that 'we mean business'. See Nelson (2007) for a favourable comparison of the Swiss inflation experience with that of another SOE, Ireland, over this period.

<sup>13</sup> The SNB's success in controlling inflation came at the cost of increased capital inflows. As noted by Gerlach and Jordan (2012), to deal with this the SNB temporarily fixed the Swiss Franc vis-à-vis the German Mark in October 1978. When it resumed monetary targeting in 1980, the SNB targeted the monetary base rather than M1.



1990s, continued to impact on real GDP (Rich 2003). Overall, GDP growth slowed substantially at this time.<sup>14</sup>

Nonetheless, by the end of the 1990s, inflation was under control again and the low inflation regime was reinforced in January 2000 when the SNB adopted an inflation targeting regime.<sup>15</sup> The business cycle downturn associated with the bursting of the dotcom bubble was followed by an upswing in the mid-2000s, and throughout inflation remained below 5%.

Following the failure of Lehman Brothers in September 2008, the downturn in the global economy increasingly came to affect the Swiss economy. Combined with low oil prices, the risk of deflation increased.<sup>16</sup> As the sovereign debt crisis in the euro area emerged, the Swiss Franc came under upward pressure. To combat this, the SNB introduced an exchange rate floor of 1.20 Swiss Francs to the euro in September 2011. However, inflation remained very low and in January 2015, with a euro area quantitative easing programme widely anticipated, the SNB removed the exchange rate floor.

### **3. Data description**

In this study, I use annual data on consumer prices and real GDP. Data availability introduces a choice between investigating a few time series for a longer sample or studying a broader range of data for a shorter sample. Since my interest is on Swiss business cycles from a historical perspective, here I elect to look at macroeconomic fluctuations for as long a sample as possible and therefore restrict the focus to these two series. Other researchers will have other preferences.

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<sup>14</sup> See Kleinewefers Lehner (2007) for a discussion. While this was initially attributed to cyclical factors, it gave way to a prolonged period of lower growth. Having averaged 2.2% from 1980-1990, growth averaged just 1.1% from 1990-2005 (Baltensperger and Kugler, 2016). During the 1990s, a series of reforms were undertaken to make Switzerland more attractive to business. See Rudolf and Zurlinden (2010) for a discussion of the possible impact of some of these reforms.

<sup>15</sup> The new monetary policy approach sets out a target for CPI inflation of “less than 2 per cent”, uses of inflation forecasts, and is implemented through a target range for 3-month Libor.

<sup>16</sup> See Gerlach and Jordan (2012).

Figure 2 shows the changes in consumer prices and real GDP over the sample period. Since the series are quite erratic, the time series is difficult to see in detail. I therefore also include in Figure 2 a smoothed version of the series, which is based on the filter applied in Lucas (1980).<sup>17</sup> This filter is equivalent to a weighted moving average which attributes a weight of 0.4 to the value at time  $t$ , weights of 0.2 to values at  $t-1$  and  $t+1$  and weights of 0.1 to values at  $t-2$  and  $t+2$ . This filter smooths the series while still indicating the direction of shocks in individual years.

It is interesting to consider how the variables perform in subperiods. Table 1 presents the mean and standard deviation of GDP growth and inflation in six economically meaningful subsamples.<sup>18</sup> In the 33 years prior to Switzerland joining the Gold Standard, inflation averaged just 0.39%, but it was extremely volatile with a standard deviation of 11.08. One possible explanation for this volatility was that services had a negligible weight in the CPI. Real GDP was also very volatile during this period, although average GDP growth, at almost 3%, was relatively high. Average real GDP growth was even higher, 3.45%, during the Gold Standard until the start of the First World War, and its volatility dropped almost a third during this period. The volatility of inflation also declined dramatically, as one would expect with the Gold Standard, and average inflation was marginally negative at -0.66%.

The First World War and interwar period was characterized by a return of volatility, perhaps unsurprisingly given the shocks associated with the War itself, the deflation in the 1920s, and the Great Depression and its aftermath. At the same

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<sup>17</sup> Lucas (1980) applies the filter:  $X_{it}(\beta) = \alpha \sum_{k=-\infty}^{\infty} \beta^{|k|} X_{i,t+k}$ , where  $\alpha = \frac{1-\beta}{1+\beta}$ ,  $0 \leq \beta < 1$ . Here, I use a truncated version of this filter in which  $-2 \leq k \leq 2$ . The weights for each time period are based on setting  $\beta$  equal to 0.5, and rebasing the weights to ensure that they sum to 1.

<sup>18</sup> The subsamples are: the period before Switzerland joined the Gold Standard from 1855 to 1878, the period on the Gold Standard to the start of the First World War, the First World War and interwar period, the Second World War, the Bretton Woods period from 1946 to 1970, and the period thereafter.

time, growth was lower than previously, at 0.97%, and inflation began to increase, averaging 1.26%. The Second World War raised both inflation and GDP. Real GDP growth increased, although it averaged a modest 1.27%, while prices grew particularly strongly, averaging 6.09%. During the post-War Bretton Woods period, volatility in both real GDP growth and inflation declined. The stability of the exchange rate regime and the 'golden age' in Europe saw inflation fall to just over 2%, and real GDP growth increase strongly, at an average rate of 4.58%. The period thereafter saw growth decline to 1.71% on average, while GDP growth volatility declined, and average inflation and its inflation remained low.

Having reviewed the data, next I turn to the econometric analysis. I first discuss the time series properties of the data before turning to the structural VAR model I use to estimate the supply and demand shocks.

#### **4. Econometric analysis**

##### *4.1 Testing for stationarity and cointegration*

In modelling real GDP and consumer prices, it is useful to first consider the stationarity of the variables. Both Augmented Dickey-Fuller (ADF) unit root tests and Elliott-Rothenberg and Stock (ERS) tests are performed on the series, with lag length selected using the Hannan-Quinn information criterion. The tests are performed including just an intercept and including both an intercept and trend. The results of the test are presented in Table 2. The upper panel of Table 2 presents the results for the variables in levels first. In all cases the test results indicate failure to reject the null of a unit root in both series. In the lower panel, the tests are performed on the variables in differences. In this instance, the null of a unit root can be rejected at the 1% level in all cases. I therefore conclude that the series are stationary in differences.

The model would be misspecified if cointegration was present and not taken into account, and I therefore next test whether the series are cointegrated. To do so first requires determining the appropriate lag length of a VAR in differences. The Schwarz, Akaike and Hannan-Quinn information criteria all indicate that three lags is the correct specification. Although a lag exclusion test suggests that the third lags are jointly insignificant (p-value = 0.26), an LM test indicates that there is serial correlation present in the second lagged error terms when two lags are used. In contrast, there is no serial autocorrelation present in the first 6 lagged error terms when three lags are included, and I therefore take this as the baseline specification.

Based on this lag length structure, a Johansen test is next used to determine whether the series are cointegrated. I perform two specifications of the test: one allows for a trend in the data and an intercept in the cointegrating equation, and the second also allows for a trend in the cointegrating equation. Perhaps unsurprisingly, given the relationship between the variables in Figure 1, in both instances the Trace test and the Maximum Eigenvalue test indicate that there is no cointegration. I therefore proceed on the basis of no cointegration, and estimate the VAR in differences (Table 3).

#### *4.2 SVAR identification of the shocks*

Incorporating only two variables in the analysis, I can only identify two shocks, which can be thought of as aggregate supply and aggregate demand shocks. Moreover, the approach to disentangling these shocks and their impact on the economy must necessarily be simple. Here I assume that aggregate supply shocks move output growth and inflation in different directions, keeping nominal GDP growth constant, while aggregate demand shocks explain movements in nominal GDP growth.

This approach implies that some economic disturbances may be captured as involving both aggregate supply and demand elements. For instance, consider a

depreciation of the exchange rate. Since it boosts the demand for domestic output and increases the price level, it may be thought of as an expansionary demand shock. However, it also increases the prices of imported inputs for Swiss firms, pushing up their production costs and reducing their willingness to supply output at the going price level. Thus, it contains an element of a contractionary aggregate supply shock.

Therefore, in estimating the VAR model, the aim is to identify the structural aggregate supply and demand shocks, which we refer to as  $u_{AS}$  and  $u_{AD}$ . To do so, I first estimate a reduced form VAR, which can be written in matrix form as:

$$Y_t = \sum_{i=1}^n A_i Y_{t-i} + e_t \quad (1)$$

Here,  $Y_t$  is a vector of endogenous variables, which in this case are: inflation and real GDP and  $Y_{t-i}$  are lagged values of these variables; in this case  $n = 3$ .

The residuals from equation (1),  $e_t$ , are referred to as the ‘reduced form’ shocks. There is one for each equation in the VAR, such that we have  $e_{cpi}$  and  $e_{gdp}$ . These reduced form shocks are combination of the structural shocks,  $u_{AS}$  and  $u_{AD}$  which we are interested in obtaining. This relationship can be written in matrix form as:

$$B e_t = C u_t \quad (2)$$

or, explicitly, as:

$$\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} e_{cpi} \\ e_{gdp} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} u_{AS} \\ u_{AD} \end{bmatrix} \quad (3)$$

To identify the structural shocks, we must make assumptions over the elements of the  $B$  and  $C$  matrices. There are a number of possible identification schemes that can be employed. One is the Cholesky decomposition which assumes  $B$  is lower triangular and  $C$  is the identity matrix. In the two variable case, this means that the first shock affects both variables at time  $t$ , while the second shock only affects one variable at time  $t$ . Such an identification structure is inappropriate in the current

setting: since the data are annual, aggregate supply and demand shocks can affect both prices and quantities within one period.<sup>19</sup>

Here, to identify supply shocks I proceed as in Ball, Mankiw and Romer<sup>20</sup> and assume that the price elasticity of aggregate demand is minus unity. In that case, an expansionary aggregate supply shock will increase GDP and reduce prices by the same percentage, leaving nominal GDP unaffected. Since that assumption can be challenged, we show below that the results are insensitive to assuming a price elasticity of -0.5 or -2.

In this case, the identifying structure is written as follows:

$$\begin{bmatrix} 1 & b_{12} \\ 1 & 1 \end{bmatrix} \begin{bmatrix} e_{cpi} \\ e_{gdp} \end{bmatrix} = \begin{bmatrix} c_{11} & 0 \\ 0 & c_{22} \end{bmatrix} \begin{bmatrix} u_{AS} \\ u_{AD} \end{bmatrix} \quad (4)$$

This implies that the impact of the aggregate supply shock on prices is given by  $1/c_{11}$ , while the impact on output is determined by  $-b_{12}/c_{11}$ . Turning to the aggregate demand shock, the impact of an aggregate demand shock on both prices and output is given by  $1/c_{22}$ .

The identification strategy allows me to consider other elasticities. For instance, theory suggests that a small, open economy which is a price-taker would have a flat aggregate demand curve, although this is only the case if all goods are tradeable. In the robustness checks in Section 6.3 I also estimate the model assuming that the price elasticity of aggregate demand is half (-0.5) and twice

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<sup>19</sup> An alternative approach follows the SVAR model studied by Bernanke, ‘Alternative Explanations for the Money-Income correlation’ who also relied on contemporaneous restrictions but constrained B in other ways than forcing it to be diagonal. Another identification scheme uses long-run restrictions, similar to those used in Blanchard and Quah, ‘The dynamic effects of aggregate demand and supply disturbances’ and Bayoumi and Eichengreen, ‘Shocking aspects of European Monetary Unification’. These restrictions assume that some shocks have no long-run impact on some variables, although all shocks have short-run effects. However, long-run restrictions such as these often give unreliable results (see Faust and Leeper, ‘When do long-run restrictions give reliable results?’ for a discussion).

<sup>20</sup> Ball, Mankiw and Romer, ‘The new Keynesian economics’.

(-2.0) as large as in the benchmark case, and discuss the impact of this change in assumption on the identified shocks.

## **5. Aggregate supply and demand shocks**

In this section I discuss the full sample results for the period 1855-2015. Of course, it is plausible that the underlying VAR has shifted in this time period. In Section 6, I then turn to a discussion of parameter stability.

### *5.1 Impact of the shocks – impulse responses*

The accumulated responses of consumer price inflation and real GDP growth to a contractionary aggregate supply shock are displayed in the first column of Figure 3, and the responses to an expansionary aggregate demand shock are presented in the second column. As implied by the identifying restrictions, the impact of the aggregate supply shock is to move inflation and GDP growth in opposite directions, while the aggregate demand shock moves both variables in the same direction.

An expansionary aggregate supply shock reduces inflation raises GDP growth, while a contractionary shock works in the opposite direction. As per the identifying assumption, aggregate supply shocks have no impact on nominal GDP growth; the increase in output is exactly offset by the decrease in prices. The impulse responses relate to a one standard deviation shock in the aggregate supply curve. We can see that the impact is quite large: inflation rises and output growth falls by 4.6% in the first year of the shock. Interestingly, most of the impact of the aggregate supply shock on the level of price and GDP are immediate; there is very little dynamics.

In contrast, an aggregate demand shock moves the economy along the aggregate supply curve, the slope of which is not determined by the identification strategy. As a result, the size of the shock is different for the two variables. Prices are

increased 1.9% in the year of the shock and output is increased by 4.2%. In this case the effect on prices rises over time and reaches about 7% five years after the shock. By contrast, the effect on the level of GDP falls over time and is insignificantly different from zero after two years.

### *5.2 Estimated aggregate supply and demand shocks*

The estimated aggregate supply and demand shocks are presented in Figures 4 and 5, respectively. Since the shocks are serially uncorrelated and erratic, I again use the filter proposed in Lucas (1980) to smooth the series. As is clear from Figure 3, the shocks are defined according to their impact on output. Thus, a positive value of the aggregate demand shock raises the price level and real GDP, and a positive value of the aggregate supply shock raises output but reduces the price level. Thus, the shocks can be thought of as expansionary aggregate demand and supply shocks.

A number of episodes in the Figures match with prior expectations of the shocks to the economy. For instance, joining the gold standard in 1878 coincides with a period of negative aggregate demand shocks. Furthermore, the First World War is marked by both a strong negative supply shock, and a strong positive demand shock. The collapse in the 1920s is marked by a sharp decline in aggregate demand, and a less marked decline in aggregate supply. The Great Depression is marked by negative aggregate demand and supply shocks, while the Second World War has a similar impact to its predecessor: a positive demand shock accompanied by a negative supply shock. The break of Bretton Woods followed the adoption of monetary targeting by the SNB in the early 1970s alongside the oil crises coincide with negative aggregate supply and demand shocks. The Global Financial Crisis and its aftermath are characterized by negative aggregate supply and demand shocks. As such, the identification of the shocks appears plausible.

An interesting point to note from the figures is that the size of the aggregate supply shocks hitting the economy has declined over the sample period, while the



aggregate demand shocks have a much less marked pattern. The finding that supply shocks have become less volatile is unsurprising, given the growth of the service sector over time, and the declining importance of the agricultural sector, where output depends on uncertain harvests, and the industrial sector, which is highly cyclical.

This issue is explored further in Table 4 which shows the standard deviation and the mean of the absolute size of the shocks during the six subperiods also considered in Table 1.<sup>21</sup> Aggregate supply shocks were largest and most volatile in the first, pre-Gold Standard subperiod. Aggregate supply shocks, in particular, decline dramatically during the gold standard period. Interestingly, aggregate demand shocks were largest and most volatile in the First World War and interwar period. Perhaps surprisingly, the Second World War period is characterized by both aggregate demand and supply shocks which are only marginally larger in size and volatility than the gold standard and Bretton Woods periods. The post Bretton Woods period is characterized by the smallest shocks and lowest volatility of the sample period. Indeed, while clearly visible, the impact of the global financial crisis, and to a lesser extent the oil crises in the 1970s, is much less strong in both aggregate supply and demand shocks than those, equally global, shocks in earlier subperiods. The implication is that the global financial crisis represented a much smaller shock to the Swiss economy than the two World Wars, the deflation in the 1920s and the Great Depression.

### *5.3 Historical decomposition*

How did these shocks impact on inflation and output growth over the last 160 years? Figures 6 and 7 show a historical decomposition of inflation and GDP growth, respectively. These indicate which shocks moved inflation and GDP growth during the sample. Turning first to inflation, it is clear that aggregate

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<sup>21</sup> By construction the shocks average to zero over the estimation period but not necessarily in each subsample. As such, taking the mean of the absolute size of the shocks gives a better indication of the size of the shocks in each subperiod.

supply shocks played a more important role than aggregate demand shocks throughout much of the early part of the sample up to the early 1890s. During the First World War period, both types of shocks are important, whereas it seems that aggregate demand shocks were particularly important in driving down prices in the early 1920s. Further aggregate demand shocks pushed down inflation during the Great Depression, and they play an important role in raising inflation through much of the 1960s up to the adoption of monetary targets in 1973. Aggregate demand shocks dominate the recent period, pushing prices below trend for the duration of the period since the global financial crisis.

Aggregate supply shocks also seem to dominate the evolution of GDP growth in the first part of the sample period. Both shocks are important through the 1890s and 1900s, but large aggregate demand shocks (both positive and negative) play an important role during the First World War. GDP growth in 1921 is pushed very far below trend by a large negative shock. However, aggregate supply shocks tend to push GDP consistently below trend during the Second World War. Negative aggregate supply shocks in the wake of the first oil crisis push GDP growth below trend for much of the 1970s and early 1980s, although the second oil crisis in 1975 is also marked by a large negative aggregate demand shock. Aggregate demand pushes GDP growth below trend in 2009 as the global financial crisis took effect throughout Europe, and thereafter both aggregate demand and supply shocks have tended to push GDP marginally below trend.

## **6. Robustness**

### *6.1 Parameter stability*

It seems highly likely that the relationship between the data changes in the 160 year period we study. I therefore next consider parameter stability. To do so, I use a Bai-Perron multiple breakpoint test for a structural break at an unknown date. I

implement this test separately for each equation in the VAR. This test first checks for a break in the parameters. If a breakdate is determined, then the sample is divided into two, and each subsample is tested separately for a break. This can be considered a test of the alternative of  $breaks = 2$  versus a null of  $breaks = 1$ . Every time a new break is found, another subsample is added until all of subsamples do not reject the null hypothesis.

When implementing this test, the minimum subsample length that is needed to perform the test must be determined. Thus, the start and end of the sample are “trimmed”, that is, used to provide preliminary and final estimates of the tested equation. Small values of the trimming percentage can lead to estimates of coefficients and variances which are based on very few observations. Since we have 161 observations, a trimming of 10% thus translates into minimum subsample periods of just 16 observations, on which we estimate 7 parameters. Since this is a rather small sample size, I run the test using a trimming of 10%, 15% and 20% and consider the findings.

An additional issue concerns the distribution of errors across regimes. Allowing the error distributions to differ across subsamples ensures robustness of the test to changes in the variance of the errors at the cost of a loss of power if the error distributions are the same across regimes. I therefore perform the test both holding the error distribution constant and allowing it to vary across subsamples.

The results of the test are presented in Table 5. The first point of note is that, for the CPI inflation equation, generally more breaks are identified when the error distribution is allowed to vary across subsamples. The opposite is true of the tests on GDP growth. It therefore appears that allowing the error distribution to vary is more appropriate for the equation with CPI as the dependent variable. This is borne out by an examination of the residuals from both regressions (Figure 8). While both series are less volatile towards the end of the sample period, it appears that the residuals from the inflation equation go through more marked periods of

high and low volatility, and that the volatility declines more at the end of the sample period.

Second, focusing on the CPI equation, using 10% and 15% trimming, breaks are identified in 1878, 1919 and 1946.<sup>22</sup> The breaks identified in the CPI equation using 10% and 15% trimming appear economically reasonable; in 1878 Switzerland joined the Gold Standard, 1919 and 1946 mark the end of the First and Second World Wars, respectively. The GDP equation identifies a break in 1925 rather than 1919, reflecting the end of the post-War deflation when trimming of 15% is used, but only one break in 1877, which is very close to that identified also in the CPI equation, when 10% trimming is used.

In contrast, when 20% trimming is used, the minimum subsample length is too large for these breaks to be identified. Instead breaks are identified very close to the new minimum subsample length of 32 years (for instance, breaks are identified 33 and 34 years after the start of the sample in the inflation and GDP growth equations, respectively). These breakdates, 1888 and 1889, have no obvious economic explanation and appear to be driven by the minimum subsample length. As such, I consider that 20% trimming may be too large, despite the advantage of increasing sample length.

I therefore proceed on the basis of the results from the 10% trimming, and re-estimate the model for 4 subperiods: 1855-1878, 1879-1919, 1920-1946 and 1947-2015.

## *6.2 Sub-sample estimates*

The VARs for the subperiods are estimated using the same specification as for the full sample to ensure comparability. The results are reported in Table 6. The impulse responses are similar to before: as per the identification strategy, aggregate supply shocks move inflation and GDP growth in opposite directions,

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<sup>22</sup> In all cases, the same breakdates are identified using both the 'sequential' and 'repartition' methods of identifying the shocks.

whereas aggregate demand shocks move both variables in the same direction, although the responses are generally less significant than the full sample estimates. This is unsurprising given the small number of observations in these sample periods (ranging from 24 to 69).

Next, I consider the shocks in comparison to those estimated across the full sample. As noted above, while the shocks by construction have zero mean in the estimation sample, this does not ensure that their mean is zero, or their variances are the same, in any subsamples. For comparison reasons, I therefore rescale the subsample shocks so that they have the same mean and variance as the full sample shock in each subsample. Finally, I combine the subsample aggregate supply and demand shocks into two full series and include them, along with the shocks estimated from the full sample VAR, in the two panels of Figure 9. Clearly, the shocks are very similar. Indeed, the correlation between the full sample shocks and the combined subsample shocks is 0.84 for aggregate demand, and 0.77 for aggregate supply. From this I conclude that, although there is some variation with the shocks estimated for the subsample periods, the full sample estimates do a good job of identifying shocks throughout the period.

### *6.3 Alternative assumptions over price elasticities*

The above shocks are identified on the basis of a price elasticity of demand of minus unity. While this specification is based on the arguments of Ball *et al.*, (1988) and seems plausible, it is of interest to explore how sensitive the results are to it. I therefore re-estimate the model assuming the price elasticity is twice (-2.0) and half (-0.5) as large. This is implemented by varying how  $u_{AD}$  is defined. Specifically, instead of setting the coefficients on the residuals from the output equations,  $e_{gdp}$ , equal to 1 as in equation (3), they are now set equal to 2.0 and 0.5. The resulting aggregate demand and supply shocks are presented in the two panels of Figure 10.

While the magnitude of the shocks is slightly different depending on the elasticity, there is little change to the sign or timing of the shocks as a result of this change in specification. Indeed, Table 7 indicates that the correlation between aggregate demand shocks when a unit elasticity is assumed and when an elasticity of -2.0 and -0.5 are assumed 0.87 and 0.91, respectively. The correlation between aggregate supply shocks when a unit elasticity is assumed and when an elasticity of -2.0 and -0.5 are assumed is also 0.87 and 0.91, respectively. Overall, these results suggest that the results are not sensitive to the assumed exact degree of price elasticity of the aggregate demand schedule.

## **7. Conclusions**

This paper studies the causes of movements in inflation and output in Switzerland over the last 160 years. To my knowledge, it is the first paper to estimate the sources of macroeconomic fluctuations in the Swiss economy over such a long time period. In addressing this gap in the literature, I use annual data on GDP and consumer price inflation in a structural VAR framework to estimate aggregate supply and demand shocks in the Swiss economy. In doing so, I use an intuitively appealing identification strategy suggested in the analysis of Ball, Mankiw and Romer (1988).

There are four main findings in the paper. First, plausible aggregate demand and supply shocks, which capture the key episodes in Swiss economic history, can be estimated for the entire sample period.

Second, the size and variance of shocks that have hit the Swiss economy have changed over the course of the sample period. In particular, the magnitude and volatility of aggregate supply and demand shocks has generally, although not uniformly, declined over the sample period. The period prior to Switzerland's joining Gold Standard, and the First World War and interwar period are marked

by large aggregate supply and demand shocks. In contrast, recent shocks such as the global financial crisis, which would generally be considered large, have had a much smaller impact on the Swiss economy than the World Wars, the deflation in the 1920s and the Great Depression.

Third the relative importance of aggregate demand and supply shocks in the evolution of GDP growth and inflation has changed over the period. The historical decomposition shows that aggregate supply and demand shocks have been important at different points. In particular, low inflation in the period after the global financial crisis appears to be driven by negative demand shocks.

Fourth, the results are insensitive to the exact degree of price elasticity of the aggregate demand curve which is used to identify the aggregate supply and demand shocks.

## **Declarations**

Availability of data and material: The data are taken from Gerlach (2016), who constructed them by splicing data series from the website *Historical Statistics of Switzerland Online*. I will make the data available on my website or in an appendix (whichever the editors prefer) if it is accepted for publication.

Competing interests: no competing interests

Funding: no additional funding

Author's contribution: this is a single authored paper

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**Table 1: Average real GDP growth and inflation**

<b>Sub-period</b>	<b>Real GDP growth</b>		<b>Inflation</b>	
	Mean	Standard deviation	Mean	Standard deviation
1855-1878	2.94	12.61	0.39	11.08
1879-1913	3.45	4.24	-0.66	4.00
1914-1939	0.97	9.04	1.26	9.32
1939-1945	1.27	5.22	6.09	5.42
1946-1970	4.58	4.64	2.08	1.90
1971-2015	1.71	2.10	2.42	2.49

**Table 2: Unit root tests, p-values and p-statistics, 1865-2015**

	<b>Augmented Dickey-Fuller test, p-value</b>		<b>Elliott-Rothenberg and Stock test, p-statistic</b>	
	<b>Intercept</b>	<b>Intercept and trend</b>	<b>Intercept</b>	<b>Intercept and trend</b>
<b>Variable</b>	<b>Levels</b>			
CPI	0.98	0.53	140.301	23.77
Real GDP	0.83	0.55	898.45	9.92
	<b>Differences</b>			
CPI inflation	-5.41***	-5.60***	0.96***	1.43***
Real GDP growth	-13.22***	-13.19***	0.16***	0.57***

Note: Lag length selected using Hannan-Quinn criterion. \*\*\*/\*\*/\* indicate significance at the 1%/5%/10% level.

**Table 3: VAR in differences, 1855-2015**

	<b>CPI inflation</b>	<b>Real GDP growth</b>
First lag CPI inflation	0.69 (0.09)	-0.24 (0.11)
Second lag CPI inflation	-0.25 (0.10)	0.05 (0.12)
Third lag CPI inflation	0.17 (0.09)	-0.12 (0.11)
First lag real GDP growth	0.42 (0.07)	-0.24 (0.09)
Second lag real GDP growth	0.17 (0.08)	-0.31 (0.09)
Third lag real GDP growth	0.04 (0.08)	0.01 (0.10)
Constant	-1.07 (0.59)	4.33 (0.73)
Log likelihood: -986.79		No. of observations: 161

Note: Standard errors in parenthesis.

**Table 4: Standard deviation and maximum absolute size of aggregate supply and demand shocks**

<b>Sub-period</b>	<b>Aggregate supply</b>		<b>Aggregate demand</b>	
	Mean absolute shock	Standard deviation	Mean	Standard deviation
1855-1878	1.50	2.11	0.70	0.94
1879-1913	0.45	0.61	0.61	0.71
1914-1939	0.81	0.99	1.18	1.84
1939-1945	0.61	0.47	0.60	0.90
1946-1970	0.41	0.43	0.64	0.78
1971-2015	0.24	0.25	0.37	0.46

**Table 5: Bai-Perron breakpoint test results**

<b>Trimming</b>	<b>CPI inflation</b>		<b>Real GDP growth</b>	
	Assuming constant error distribution	Allowing error distribution to vary	Assuming constant error distribution	Allowing error distribution to vary
10%	1879	1878, 1919, 1946	1878	-
15%	1879	1878, 1919, 1946	1879, 1926	-
20%	1889	1889, 1922	1890, 1923	1923

**Table 6: VAR in differences, results, 1855-2015**

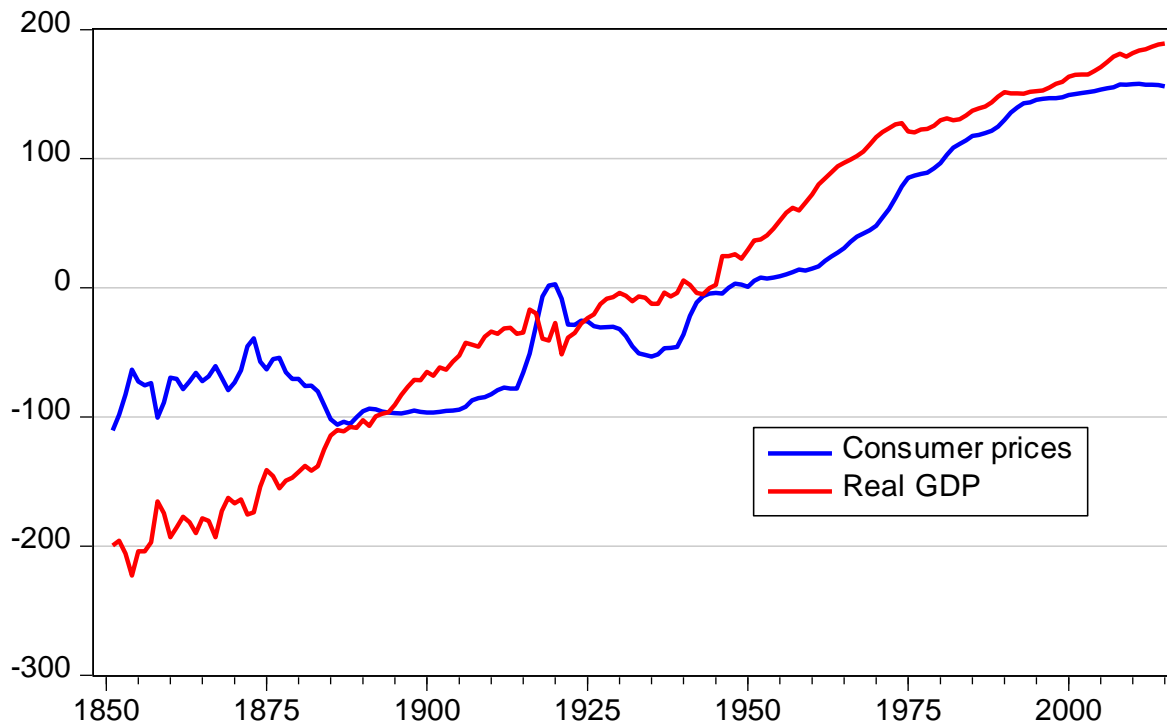
	1855-1878		1879-1919		1920-1946		1947-2015	
	CPI inflation	Real GDP growth	CPI inflation	Real GDP growth	CPI inflation	Real GDP growth	CPI inflation	Real GDP growth
First lag CPI inflation	0.71 (0.46)	-0.68 (0.52)	0.98 (0.16)	0.03 (0.22)	1.50 (0.17)	0.32 (0.48)	0.72 (0.13)	-0.57 (0.21)
Second lag CPI inflation	0.02 (0.55)	0.13 (0.62)	-0.17 (0.23)	-0.44 (0.30)	-1.16 (0.21)	-0.57 (0.60)	0.02 (0.16)	-0.04 (0.28)
Third lag CPI inflation	-0.80 (0.43)	1.08 (0.49)	0.07 (0.20)	-0.24 (0.27)	0.38 (0.15)	0.22 (0.42)	0.12 (0.13)	0.23 (0.21)
First lag real GDP growth	0.52 (0.41)	-0.55 (0.46)	0.23 (0.13)	-0.27 (0.17)	-0.03 (0.10)	-0.53 (0.28)	0.32 (0.05)	0.08 (0.09)
Second lag real GDP growth	0.53 (0.52)	-0.40 (0.58)	0.07 (0.13)	-0.54 (0.17)	-0.34 (0.09)	-0.19 (0.27)	-0.02 (0.07)	0.15 (0.11)
Third lag real GDP growth	-0.84 (0.45)	1.10 (0.51)	-0.20 (0.14)	-0.24 (0.19)	0.46 (0.11)	0.34 (0.30)	-0.04 (0.06)	-0.04 (0.10)
Constant	0.43 (4.01)	0.81 (4.50)	0.33 (1.04)	6.11 (1.38)	0.12 (0.62)	3.36 (1.79)	-0.40 (0.41)	2.72 (0.69)
	Obs: 24		Obs: 41		Obs: 27		Obs: 69	

Note: Standard errors in parenthesis.

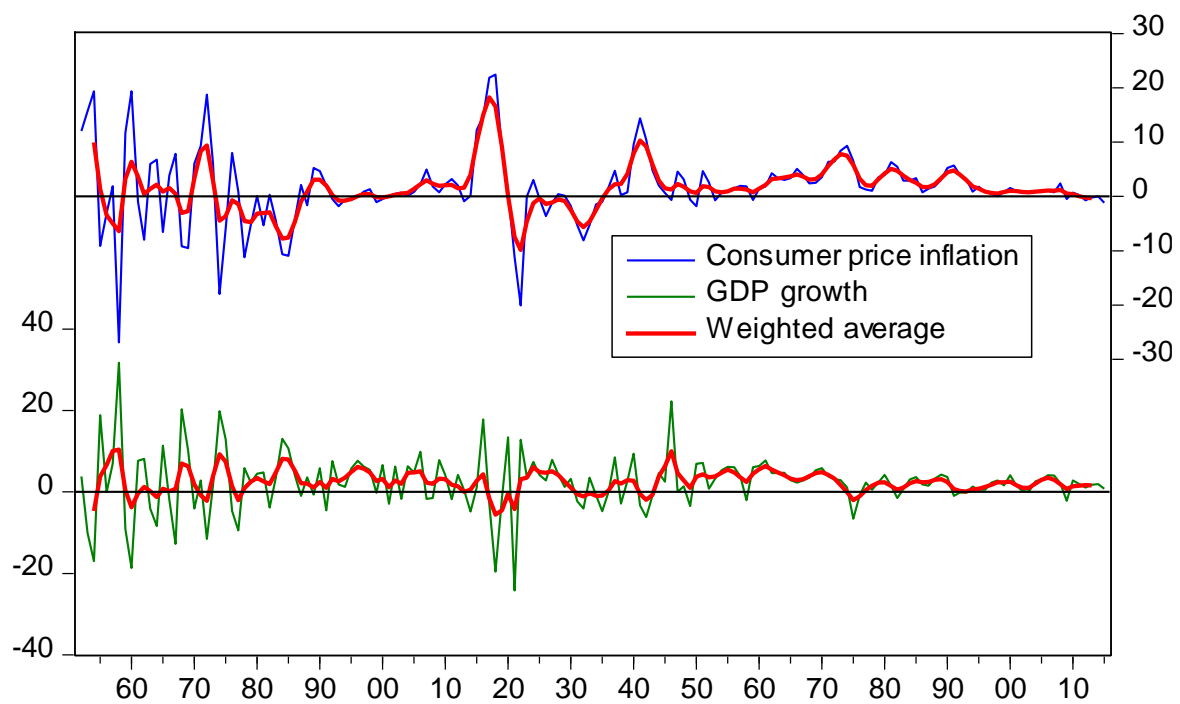
**Table 7: Correlation of shocks under assumption of varying price elasticities**

	<b>Aggregate supply</b>	<b>Aggregate demand</b>
<b>Price elasticity</b>	Price elasticity = -1.0	
-2.0	0.87	0.87
-1.5	0.91	0.91

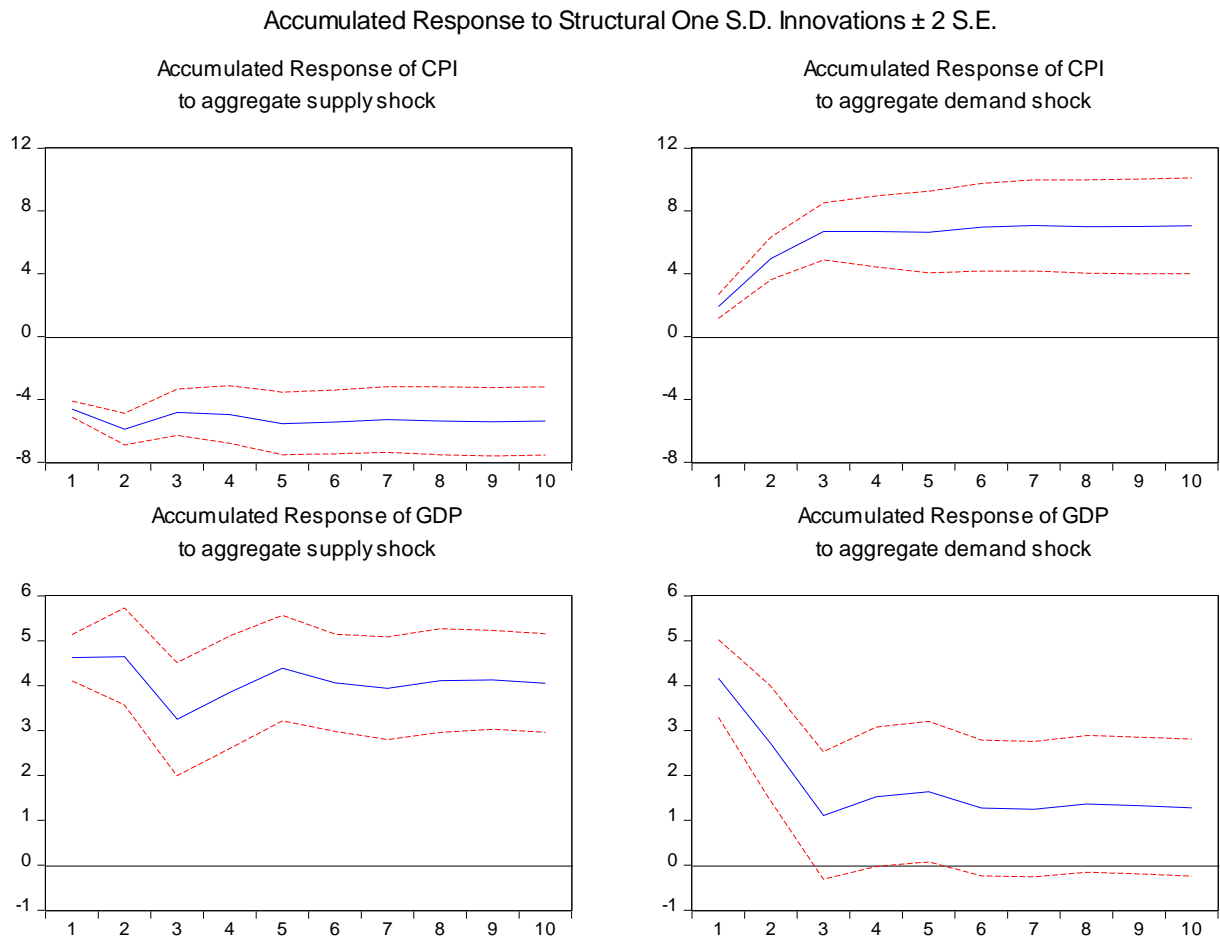
**Figure 1: Consumer prices and output, demeaned log levels, 1855-2015**



**Figure 2: Consumer price inflation and output growth, 1855-2015**

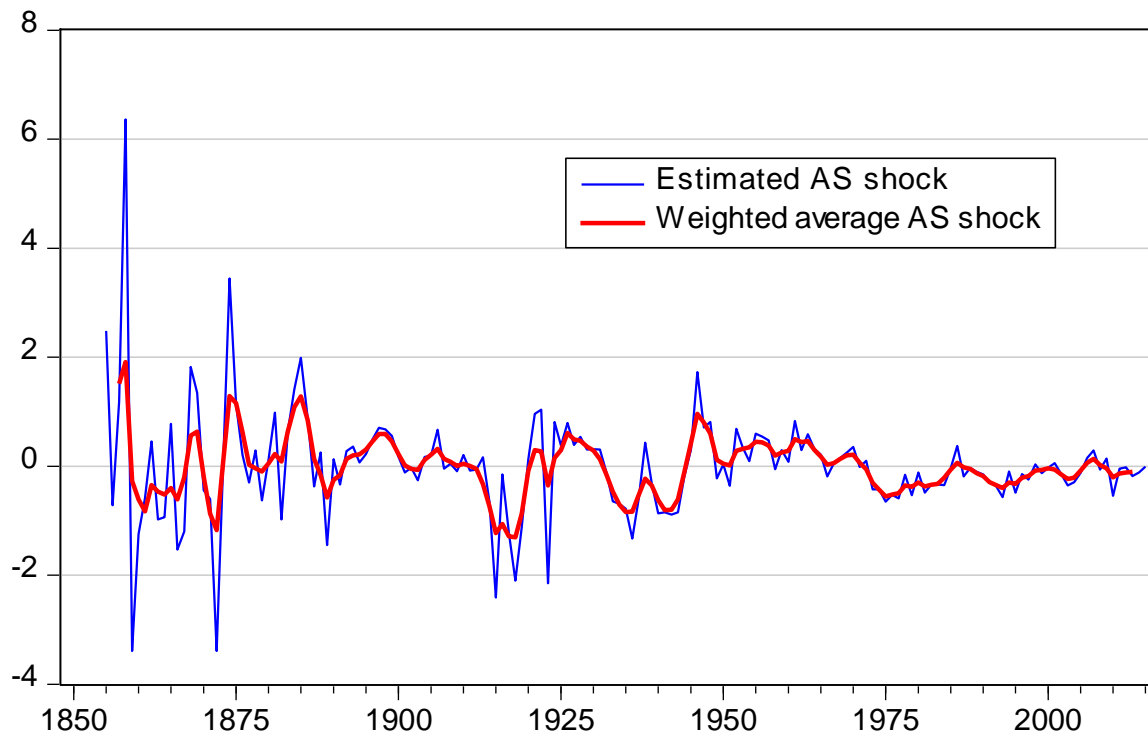


**Figure 3: Impulse responses to aggregate demand and supply shocks**

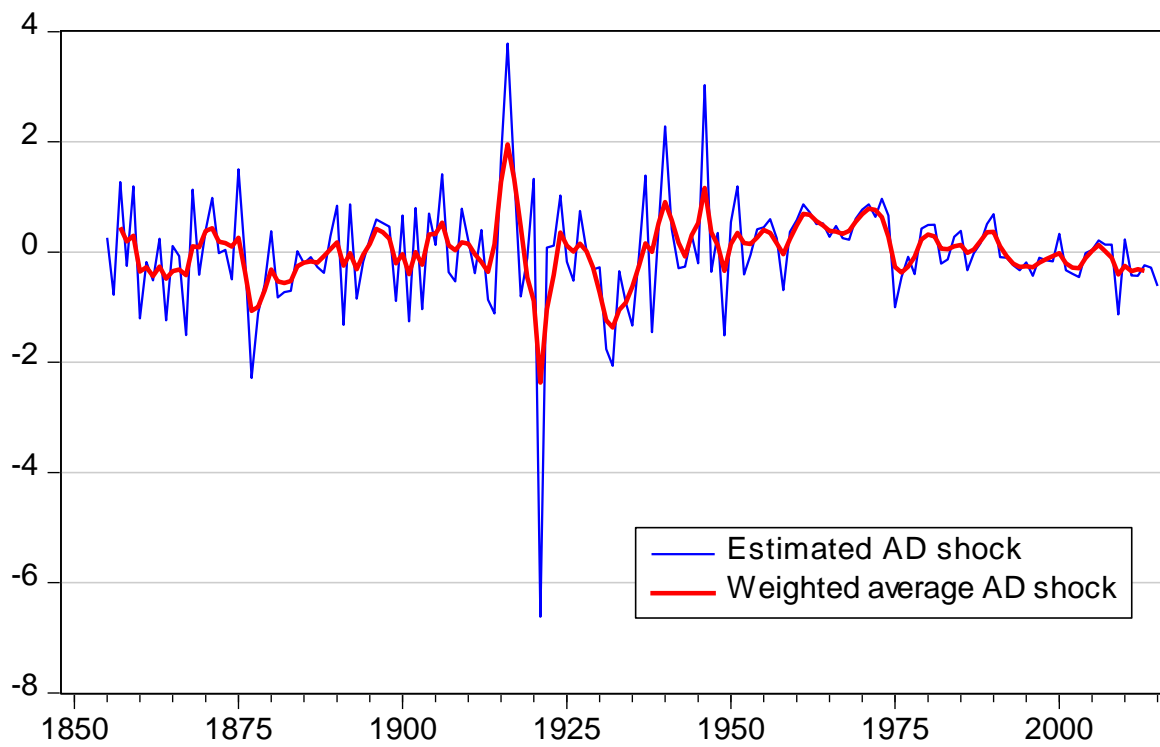




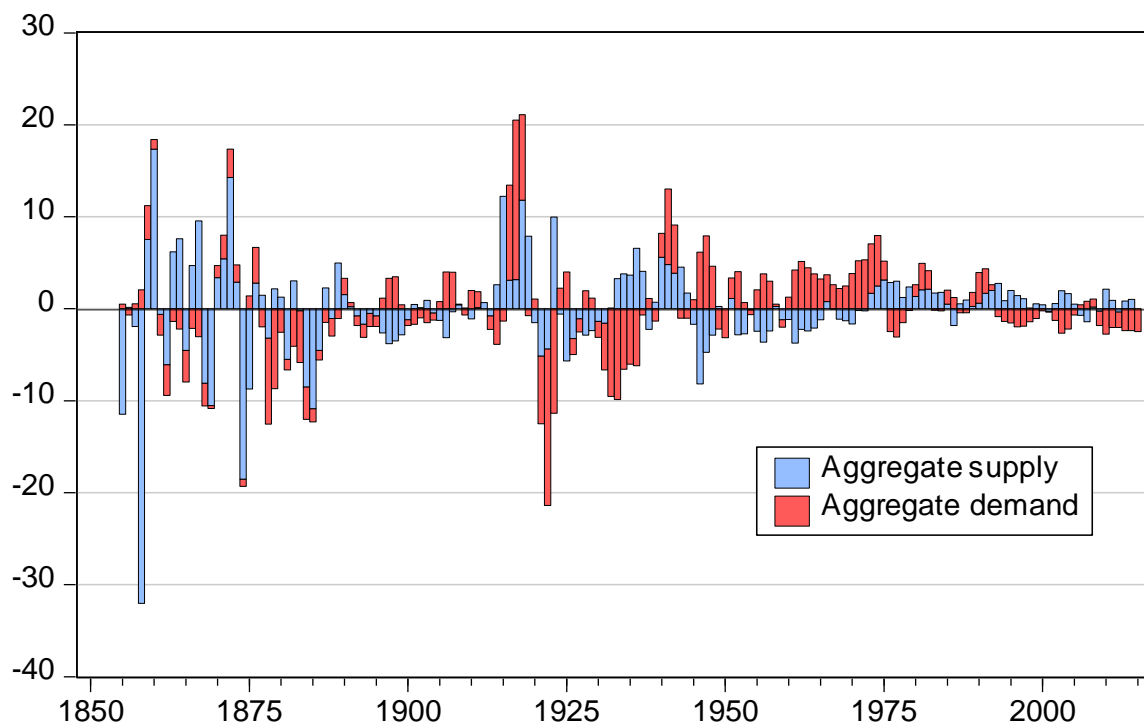
**Figure 4: Estimated and weighted average aggregate supply shock**



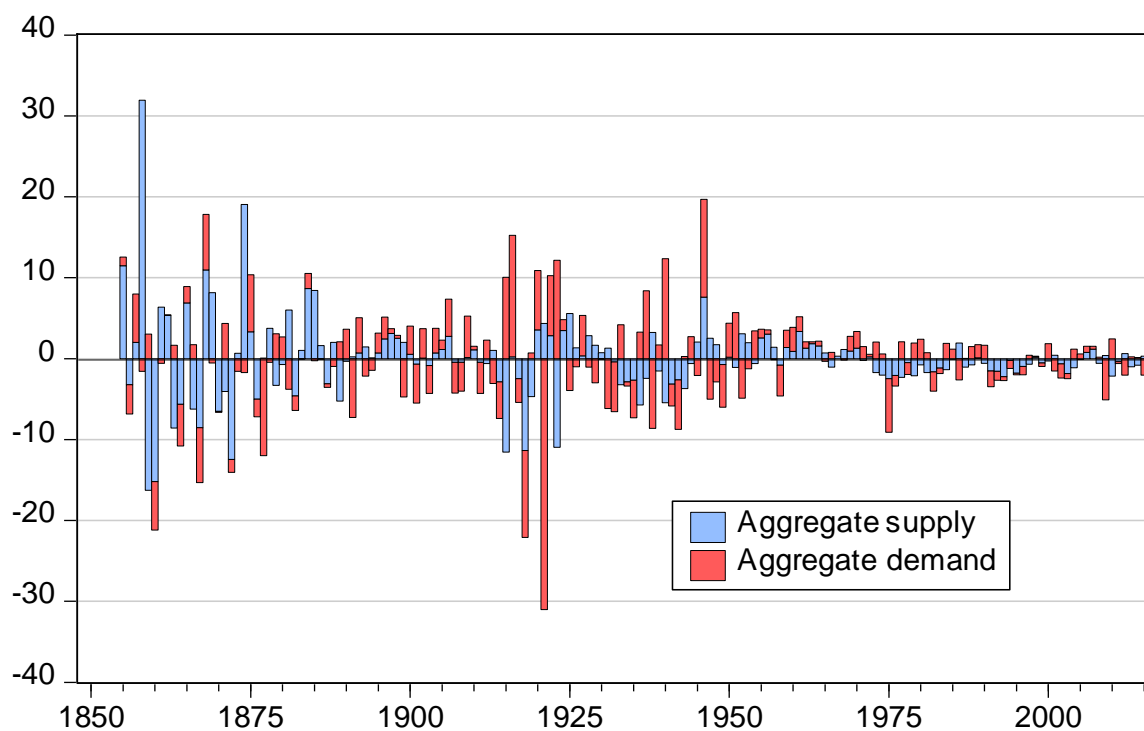
**Figure 5: Estimated and weighted average aggregate demand shocks**



**Figure 6: Historical decomposition of inflation, 1855-2015**



**Figure 7: Historical decomposition of real GDP growth, 1855-2015**



**Figure 8: Residuals from single equation regressions**

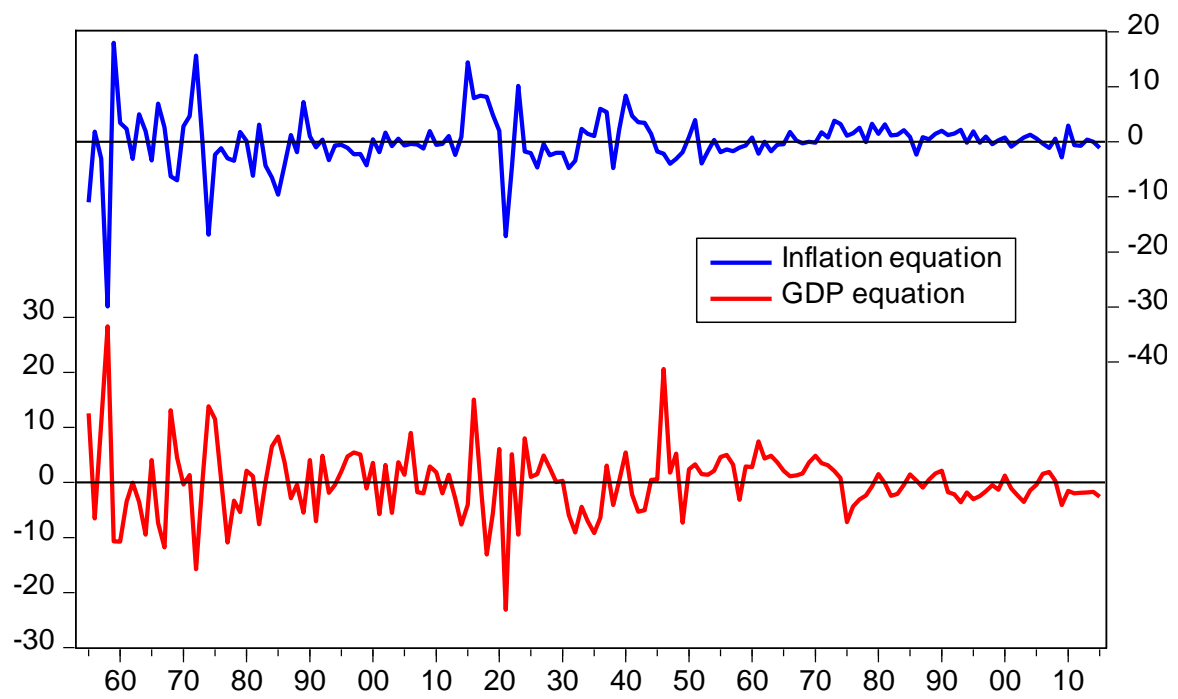


Figure 9: Aggregate supply and demand shocks, subperiod and full sample estimates

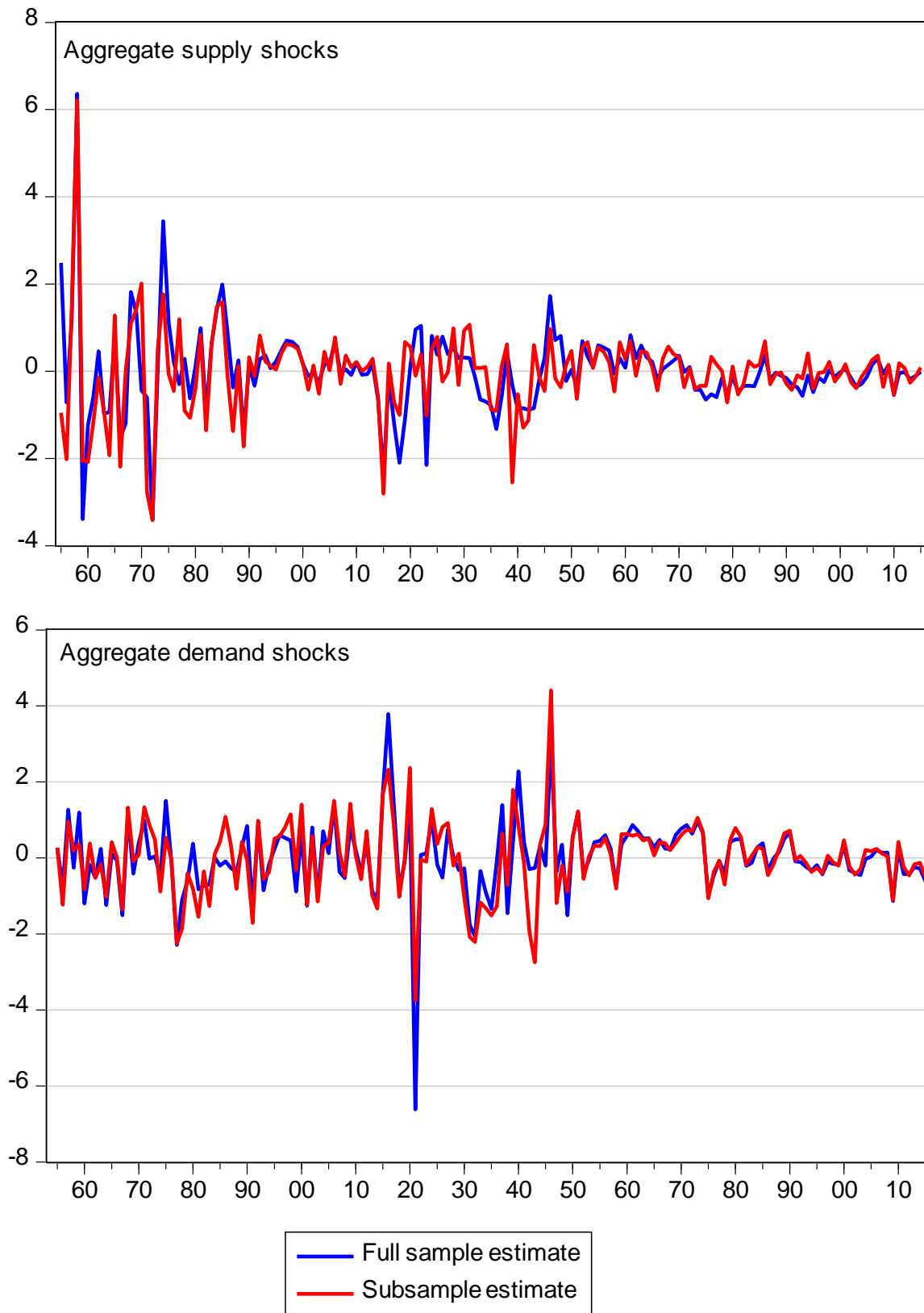


Figure 10: Aggregate supply and demand shocks under varying assumptions of price elasticity of demand (PED)

