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160 Years of Aggregate Supply and Demand in Switzerland

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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 World Wars, the deflation of the 1920s and the Great Depression represented much larger shocks than either of 1970s break-up of Bretton Woods and move to floating exchange rates or the Global Financial Crisis.

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

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1. Introduction

This paper studies economic fluctuations in Switzerland over the last 160 years. A complete analysis would require an assessment of a wide range of economic phenomena such as changes in technology, demographic changes including in the size and composition of the labour force, and the availability and cost of capital, to mention just a few. The level of ambition here is more modest. The paper takes a small but important forward step by providing an econometric study of Swiss business cycles over the period 1855 to 2015. The 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 in output and inflation. Previous studies have discussed the development of the Swiss economy in this period, while others have considered econometrically those forces acting on the economy over shorter samples. However, I am not aware of a study that provides econometric estimates of supply and demand shocks impacting on the Swiss economy over such a long period.

Since few data series are available for such an extended sample, I focus on annual data on GDP and consumer prices. To estimate the aggregate supply and demand shocks and study their economic effects, a structural VAR framework is employed. Using only these time series, it is difficult to think of how to identify supply and demand shocks. I make use of 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 variance and historical decompositions of their effects on GDP growth and inflation are provided.

The long sample period, which begins in 1855 and ends in 2015, covers several important episodes in Swiss economic history, including the establishment of a Swiss monetary system in the 19th century, 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 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 can answer a number of questions which have not previously been addressed in the literature.

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. The first two to three decades of the sample are characterized by numerous sizeable aggregate supply shocks. Although this is followed by 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. Indeed, the analysis shows that the effects of the global financial crisis on the Swiss economy were much smaller than the First and Second World Wars, the deflation of 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 depressed prices 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 early part of the sample. Negative aggregate supply shocks play an important role in holding back GDP growth during the two

World Wars, although they are offset by strong demand shocks. Much of the 1950s and 1960s are characterized by positive aggregate supply shocks. The opposite is true after the first oil crisis and adoption of monetary targeting in the early-1970s. 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 context

To put the discussion below in context, I start by providing the historical background. Figure 1 shows real GDP and CPI in log levels. In the 19th century, Switzerland was one of the early industrializing countries, characterized by both high industrial employment and successful engagement in international markets. Indeed, Bordo and James (2007, p. 30) refer to it as *'a prime example of a highly open economy'*. By the turn of the 20th century, approximately 40% of the workforce was employed in the industrial sector, while the gross value added by the agricultural sector had declined by about a quarter compared to the 1890s (Gugerli et al., (2012)). This industrialization transformed Switzerland from a net emigration to a net immigration country. An increase in the number of patents during this period points to a switch from technology-importing to technology-exporting and the high degree of self-financing of companies and the relatively low dependence on foreign capital point to a relatively high level of prosperity by the end of the 19th century (Gugerli et al., (2012)).

The monetary system of Switzerland was also established during this period. It was based largely on that of France, and Switzerland became a founding member of the Latin Monetary Union – dominated by France – in 1865. The Franco-Prussian War triggered a liquidity crisis (the *Geldcrisis*, see Baltensperger and Kugler (2017)) which highlighted the fragmentation of the Swiss financial system. To address this, the Banknote Act (1881) standardized note issuance and required convertibility of all bank notes at par regardless of their origin. The Act is generally seen to divide the free banking era in Switzerland in two: with unrestricted free-banking occurring before 1881, and a much more tightly regulated regime after (Herger (2022)). Kaufmann and Stuart (2022) find that the introduction of the Act coincides with improved financial integration in Switzerland. Overall, prices remained steady at close to the level in the 1850s until the outbreak of the First World War.

The suspension of gold convertibility by many countries during the First World War impacted Switzerland as an exporting economy: exports and imports fluctuated markedly and prices more than doubled during this period (Bordo and James (2007)) (Figure 1).[1] 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.[2]

The end of the War is marked by an abrupt reversal in consumer prices and a severe economic slump characterized by both deflation and marked unemployment.[3] However, the SNB, which was established in 1907, re-established the pre-War gold

[1] 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.

[2] Baltensperger and Kugler (2016, p. 59).

[3] Baltensperger and Kugler (2016) report that unemployment rose from 3,500 registered workers seeking employment in 1920 to approximately 100,000 in 1922.

parity 1925[4], and the relatively quick resumption of monetary - and social - stability after the War meant that Switzerland was able to consolidate its position in foreign markets as international trade regained some normality. Both GDP growth and real wages increased strongly in the 1920s compared to other European countries, driven largely by an increase in labor force participation of the working age population (Gugerli et al., (2012)).

The period of strong growth was cut short by the Great Depression. Financial market upheavals abroad spread to Switzerland in 1931. However, the damage was relatively limited since much of the population had not engaged in speculative activities in the stock market. Similarly, cantonal banks, which focused mainly on Swiss customers, generally did not experience major problems, although banks with large investments abroad came under pressure. Two phases can be identified: for 3-4 years after 1929, there was a decline in many domestic and export sectors. Indeed, Swiss industrial production fell 21% from 1929 to 1932.[5] However, the construction sector was a notable exception, experiencing a sustained upswing during these years. Thereafter, there was some recovery, particularly in exporting industries, first in watchmaking and then in textiles and machine industries, but the construction industry experienced a sharp slump.[6] Internationally, Switzerland was one of the last countries to devalue its currency, waiting until 1936 and thus delaying the subsequent upswing.[7]

Prices began to rise again at the start of the Second World War, exacerbated by large gold inflows. Moreover, the growth rate in Switzerland turned negative again, albeit less so than elsewhere in Western Europe. The gold inflows proved controversial in the post-War era, playing a role in Switzerland's initial economic

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[4] 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).

[5] See Zurlinden (2003) for a discussion of the impact of the Great Depression on Switzerland.

[6] See Gugerli et al., (2012) for a discussion of the two phases of the Great Depression in Switzerland.

[7] Bordo and James (2007) note that France, the Netherlands and Switzerland stayed on the gold standard longer than any other European country.

isolation. Only a series of negotiated agreements with the Allied powers brought an end to this, and enabled exports and GDP growth to resume an upward trajectory in the post-War period (Bernholz (2007)). Growth was strong in the 1950s and 1960s, however, this 'golden age' was also experienced in much of the rest of Europe. As a result, real wages rose in Switzerland, but in a similar manner to other European countries. [8]

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.[9] 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[10], began to encounter 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.[11] The oil crisis in 1975 was an international shock, but the resulting economic slump was severe in Switzerland, since it was combined with particularly restrictive monetary policy (Rich (2003)). 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)).

[8] Only in Germany did real wages increase more sharply. This is in line with the increases in GDP per capita there, which increased strongly because of the low base at the beginning of the 1950s (Gugerli et al., (2012)).

[9] 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).

[10] 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.

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

The international liberalization of capital markets following the collapse of Bretton Woods did not mean a drastic change for Switzerland, with its traditionally open capital market. Instead, it provided a strong growth impetus for Switzerland as an international financial centre. Indeed, in the subsequent period employment in the industrial sector declined markedly while that in the services sector increased.[12] The export-oriented services sector went from contributing a quarter of economic growth to contributing almost half, with all of this increase arising from the financial sector.

In addition to the monetary upheaval, in the 1970s another structural change occurred as measures to control immigration coincided with a reduction in labour market flexibility. As a result, the incentives for companies to relocate production abroad increased. The 1980s also saw growth in employment, not only due to the increase in foreign workers, but also to an increase in labour force participation among women. Towards the end of the 1980s, concerns regarding the international economic environment led the SNB to maintain a looser policy than might otherwise have been the case. These concerns did not fully materialize, however, and inflation rose, triggering a housing bubble which burst in the early-1990s causing severe problems for Swiss mortgage banks (Rich (2003)).

Structural change in the 1990s saw the share of domestic industry in GDP decline by a half, while the share of export industry increased, partly because several previously domestically oriented industries refocused on exports. Export-oriented services accounted for almost all of the economic growth during this period, which was relatively weak by international comparison in the 1990s. The contributions to economic growth became more balanced across the economy in the period up to 2005 however, with export-oriented industry and the domestic economy becoming more important.

[12] See Gugerli et al., (2012) for a discussion of the structural change in the Swiss economy in the 1970s to 1990s.

By the end of the 1990s, inflation was low and in January 2000 the SNB adopted a policy strategy in many ways similar to inflation targeting.[13] 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.[14] 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.

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

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[13] 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.
[14] See Gerlach and Jordan (2012).

on the filter applied in Lucas (1980).[15] This filter is a centered five-year moving average with 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* ad *t+*2.

It is interesting to consider how the variables evolve in different subperiods. Table 1 presents the mean and standard deviation of GDP growth and inflation in six economically meaningful subsamples.[16] In the 35 years prior to Banknote Act of 1881, inflation averaged -0.27%, but it was extremely volatile with a standard deviation of 10.69. One possible explanation for this volatility was that the CPI was based on a relatively small number of items, mainly commodities, with services having a negligible weight. Real GDP was also very volatile during this period, although average GDP growth, at just over 3%, was relatively high. Average real GDP growth was even higher, 3.39%, during the subsequent period of stability 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, and average inflation remained negative at -0.23%.

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 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

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[15] 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 β equal to 0.5 and rebasing the weights to ensure that they sum to 1.

[16] The subsamples are: the period from 1855 until the Banknote Act (1881), the subsequent period 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.

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

In modelling real GDP and consumer prices, it is useful to first consider the stationarity of the variables. I apply both Kwiatkowski, Phillips, Schmidt and Shin (KPSS) stationarity tests and Phillips-Perron unit root tests. 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. In the case of the KPSS tests, the null of stationarity is rejected in all cases with the exception of real GDP when a trend and intercept are included. Turning to the results of the Phillips-Perron unit root tests, the results indicate a failure to reject the null of a unit root for both series.

In the lower panel, the tests are performed on the variables in differences. In this instance, the null of stationarity cannot be rejected in all cases using the KPSS test, while the null of a unit root can be rejected at the 1% level using the Phillips-Perron test. Overall, I conclude that the series are stationary in differences.[17]

[17] The model would be misspecified if cointegration was present and not taken into account. Perhaps unsurprisingly given the relationship between the variables in Figure 1, applying the Trace and the Maximum Eigenvalue tests points to no cointegration, regardless of whether the specification allows for a trend in the data and an intercept in the cointegrating equation or for a trend in the cointegrating equation.

4.2 VAR and structural identification of the shocks

To analyse the data, I estimate a structural VAR. With only two variables, 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 opposite 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.

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}, that are assumed to have zero mean, unit variance and to be uncorrelated. To do so, I first estimate a reduced form VAR, which can be written in matrix form as:

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

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:

$$Be_t = Cu_t \qquad (2)$$

or, explicitly, as:

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

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 seems inappropriate in the current setting: since the data are annual, aggregate supply and demand shocks most likely affect both prices and quantities within one period.

To identify supply shocks, I proceed as in Ball et al., (1988) and assume that the price elasticity of aggregate demand is minus unity. In this case, the identifying structure is written as follows:

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

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

Before proceeding, I note that there are alternative methods for estimating the VAR and identifying the shocks. For instance, the model could be estimated using Bayesian, rather than classical, techniques, and the shocks could be identified using sign restrictions or long run restriction as proposed by Blanchard and Quah (1989).[18] Given the array of choices, some selection must be made. In this paper, I have chosen the most simple and intuitive identification scheme. I leave it to future work to employ alternative methods to study these data.

Finally, in terms of lag length selection in the VAR, the Schwarz, Akaike and Hannan-Quinn information criteria all point to using three lags. 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 when three lags are included, and I therefore adopt this specification. The estimates of the VAR in differences are in Table 3.

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 therefore 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

[18] Also implemented, for instance, by Bayoumi and Eichengreen (1992). However, Faust and Leeper (1997) argue that long-run restrictions such as these often give unreliable results. A further alternative approach follows the SVAR model studied by Bernanke (1986) who also relied on contemporaneous restrictions but constrained B in other ways than forcing it to be diagonal.

3, and the responses to an expansionary aggregate demand shock are presented in the second column. The impulse responses relate to a one standard deviation shock. Standard errors are bootstrapped and 95% confidence bands are included in the Figure.

The estimated impact of an aggregate supply shock 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 prices 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 by 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.

The effect on the level of GDP falls over time and it becomes insignificantly different from zero for most horizons after two years, although the result is marginal. This insignificance is compatible with traditional view that unexpected changes to trend GDP are caused only by labor supply, total factor productivity and other supply side shocks while aggregate demand shocks have only transitory effects on real GDP (Blanchard (2018)). Indeed, Blanchard and Quah's (1989) SVAR identification scheme is based on demand shocks having no permanent impact on output. On the other hand, empirical studies have frequently found evidence of hysteresis – a permanent effect on output – arising from aggregate demand shocks.[19] For instance, Cerra and Saxena (2017) study data on 192 countries and find that there is a permanent impact on GDP of all types of shocks. Similarly, Blanchard, et al., (2015) look at 122 recessions 23 countries over 50 years and find evidence of hysteresis

[19] See Cerra et al., (2020) for a review of the recent literature.

following approximately two thirds of recessions. Their results hold for recessions that were plausibly induced by demand shocks. Overall, as noted by Furlanetto et al., (2021), the debate on the impact of aggregate demand shocks on output is not yet closed. A benefit of the identification scheme used here is that it does not take a stand on this issue.

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.

A number of episodes in the Figures match with prior expectations of the shocks to the economy. For instance, the Franco-Prussian War and the associated *Geldcrisis* in Switzerland coincide 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 attributable to 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-up of Bretton Woods and 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 pattern is particularly notable in the strong growth years of the post-War period, and even more so in the most recent period when the economy went through a process of de-industrialization. This finding is unsurprising, given the growth of the service sector, and the declining importance of first the agricultural sector, where output depends on uncertain harvests, and later 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.[20] Aggregate supply shocks were largest and most volatile in the first subperiod. They decline dramatically in the wake of the Banknote Act (1881). 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 which are similar in size and volatility to those during the period of stability after the Banknote Act of 1881 and during the Bretton Woods periods. Aggregate supply shocks during the Second World War are somewhat larger compared to these periods, but small compared to the early sample period and the First World War and interwar period.

The post-Bretton Woods period is characterized by the smallest shocks and lowest volatility of the sample period as services became increasingly important. Indeed, the impact of the global financial crisis, and to a lesser extent the impact of the break-up of Bretton Woods and the move to floating exchange rates, is much less pronounced in the estimated aggregate supply and demand shocks than the global shocks in earlier subperiods.

5.3 Variance and historical decompositions

How did these shocks impact on inflation and output growth over the last 160 years? The variance decompositions in Figure 6 show how much of the variance of

[20] 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.

inflation and GDP growth is explained by each of the shocks. The aggregate supply shock accounts for a relatively larger share of the variance in inflation (between 60% and 85%) compared to the aggregate demand shock (between 15% and 40%). In the case of GDP growth, the importance of the two shocks is more equal: aggregate supply shocks account for between 51% and 55% of the variance in GDP growth.

To consider which shocks moved inflation and GDP growth at different points in the sample, Figures 7 and 8 show a historical decomposition of inflation and GDP growth, respectively. Turning first to inflation, aggregate 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 dominate 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 Bretton Woods collapse and the first oil crisis push GDP growth below trend for much of the 1970s and early 1980s, while 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 studied. 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 9). 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.[21] The breaks identified in the CPI equation using 10% and 15% trimming appear economically reasonable; the break in 1878 is a little before the introduction of the Banknote Act in 1881 but this was also a decade of upheaval both in terms of the Franco-Prussian War and the international monetary regime[22], 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

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[21] In all cases, the same breakdates are identified using both the 'sequential' and 'repartition' methods of identifying the shocks.

[22] For instance, Herger (2022) notes that changes in relative prices of metals during the decade drove an increase in demand for silver coins, which being heavy, increased demand for banknotes to settle large transactions. The ongoing lack of standardization of banknotes continued until 1881: an amendment to the federal Constitution aimed to standardize and unify banknotes was rejected by a popular referendum in 1876.

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, do not have as obvious an 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 larger sample length.

I therefore proceed based on 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 those reported for the full sample: as per the identification strategy, aggregate supply shocks move inflation and GDP growth in opposite directions, 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 subsample. 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.

The results are shown in the two panels of Figure 10. 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 based on an assumed 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. The resulting aggregate demand and supply shocks are presented in the two panels of Figure 11.

While the magnitude of the shocks depends on the elasticity assumed, 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 exact degree of price elasticity of demand assumed.

6.4 Alternative estimates of output and prices

Stohr (2016) calculates alternative estimates of Swiss output which emphasise the importance of trading gains for periods spanning from 1851 to 2006. Estimates from 1851 are available on single-deflated measures of output. The main feature of these data is that they account for gains from relative price changes such as the terms of trade and from the real exchange rate. Thus, the data hold only the general price level constant but allow for relative price changes. This methodology is particularly useful when the focus is on living standards or welfare.

I use three measures of single-deflated output: real GDI, single-deflated value added (SDVA) and a compromise measure which is a geometric mean of the first two measures.[23] The pairwise correlations between these output measures and the real GDP growth rates used in the baseline model range from 0.65 to 0.68. In addition, Stohr presents a nominal value-added series, which can be used alongside these measures of output to calculate three different deflators.[24] The pairwise correlations between these deflators and the inflation series used in the baseline are between 0.66 and 0.68.

I re-run the analysis using these alternative data series. In each case I estimate a VAR and identify the shocks as discussed in Section 4 above, and then use Lucas' filter to compare the estimated aggregate supply and demand shocks using these alternative measures of output and inflation with the baseline shocks. As is evident from Figure 12, the estimated shock series are very similar. The main difference arises in aggregate supply shocks in the early part of the sample prior to the introduction of the Banknote Act in 1881: the shocks estimated using Stohr's data are somewhat smaller than the baseline shocks. Nonetheless, the shocks remain volatile during this period and the overall pattern in terms of the timing and sign of the shocks is the same. These differences end in the mid-1880s, after which the series become very alike.

In terms of the aggregate demand shocks, the shocks are even more similar: here the correlation between the baseline estimated shock and those calculated using Stohr's data is never less than 0.93. Overall, it seems the exact choice of data used in obtaining the baseline estimates is not driving the result.

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[23] See sections 3.1, 3.2 and 4.1, respectively, of Stohr (2016) for details on how these series are constructed.

[24] The nominal value added series ends in 1990. It is therefore extended to 2006 using the a nominal GDP calculated using the expenditure method, which is identical to the nominal value added series for the period in which the two overlap (1892-2006).

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 in such a long sample. 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 the Banknote Act of 1881, and the First World War and interwar period are marked by large and volatile aggregate supply and demand shocks. In contrast, important recent shocks such as the global financial crisis 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.

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Table 1: Average real GDP growth and inflation

	Real GDP growth		Inflation	
Sub-period	Mean	Standard deviation	Mean	Standard deviation
1855-1880	3.09	11.85	-0.27	10.69
1881-1913	3.39	4.41	-0.23	3.63
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 and stationarity tests, statistics and 5% critical values, 1855-2015

	Kwiatkowski-Phillips-Schmidt-Shin test		**Phillips-Perron unit root test**	
	Intercept	**Intercept and trend**	**Intercept**	**Intercept and trend**
Variable	Levels			
CPI	1.41*** (0.46)	0.31*** (0.15)	0.53 (-2.88)	-2.26 (-3.44)
Real GDP	1.55*** (0.46)	0.09 (0.15)	-1.22 (-2.88)	-3.25 (-3.44)
	Differences			
CPI inflation	0.33 (0.46)	0.07 (0.15)	-9.06*** (-2.88)	-9.03*** (-3.44)
Real GDP growth	0.09 (0.46)	0.04 (0.15)	-14.83*** (-2.88)	-14.86*** (-3.44)

Note: 5% critical value in parenthesis. ***/**/* indicate significance at the 1%/5%/10% level.

Table 3: VAR in differences, 1855-2015

	CPI inflation	Real GDP growth
First lag CPI inflation	0.69	-0.24
	(0.09)	(0.11)
Second lag CPI inflation	-0.25	0.05
	(0.10)	(0.12)
Third lag CPI inflation	0.17	-0.12
	(0.09)	(0.11)
First lag real GDP growth	0.42	-0.24
	(0.07)	(0.09)
Second lag real GDP growth	0.17	-0.31
	(0.08)	(0.09)
Third lag real GDP growth	0.04	0.01
	(0.08)	(0.10)
Constant	-1.07	4.33
	(0.59)	(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

	Aggregate supply		Aggregate demand	
Sub-period	Mean absolute shock	Standard deviation	Mean	Standard deviation
1855-1880	1.37	1.99	0.70	0.92
1881-1913	0.46	0.62	0.60	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

	CPI inflation		Real GDP growth	
Trimming	**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

	Aggregate supply	Aggregate demand
Price elasticity	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

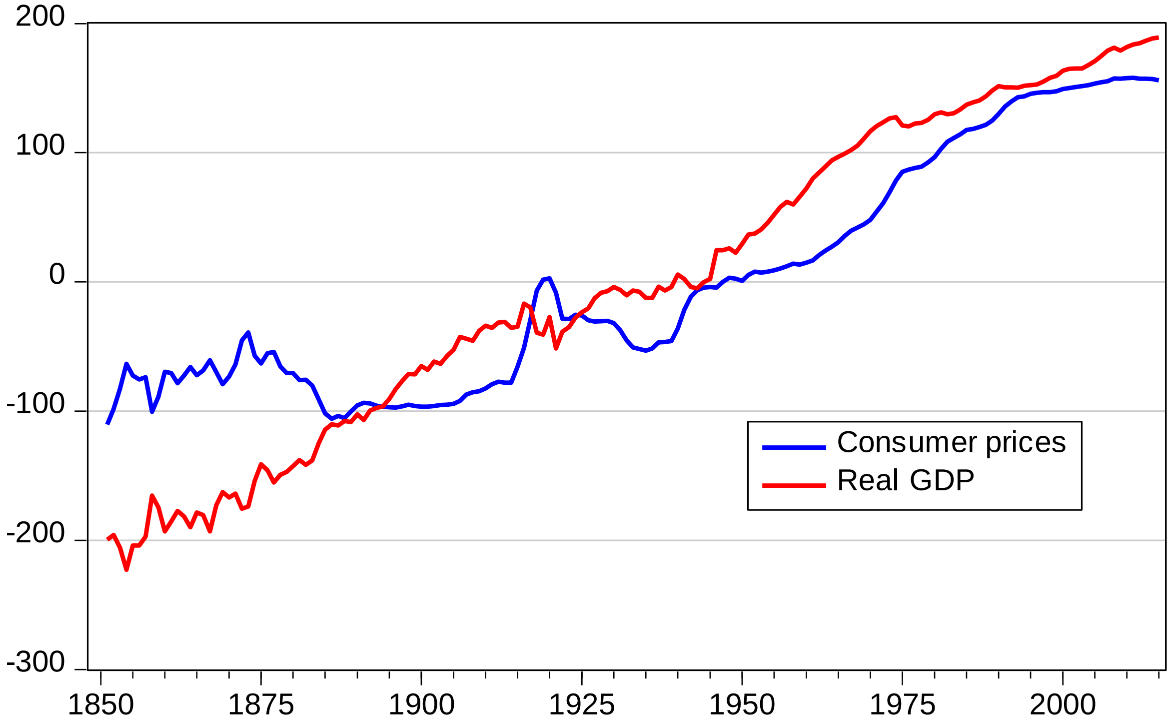

Figure 2: Consumer price inflation and output growth, 1855-2015

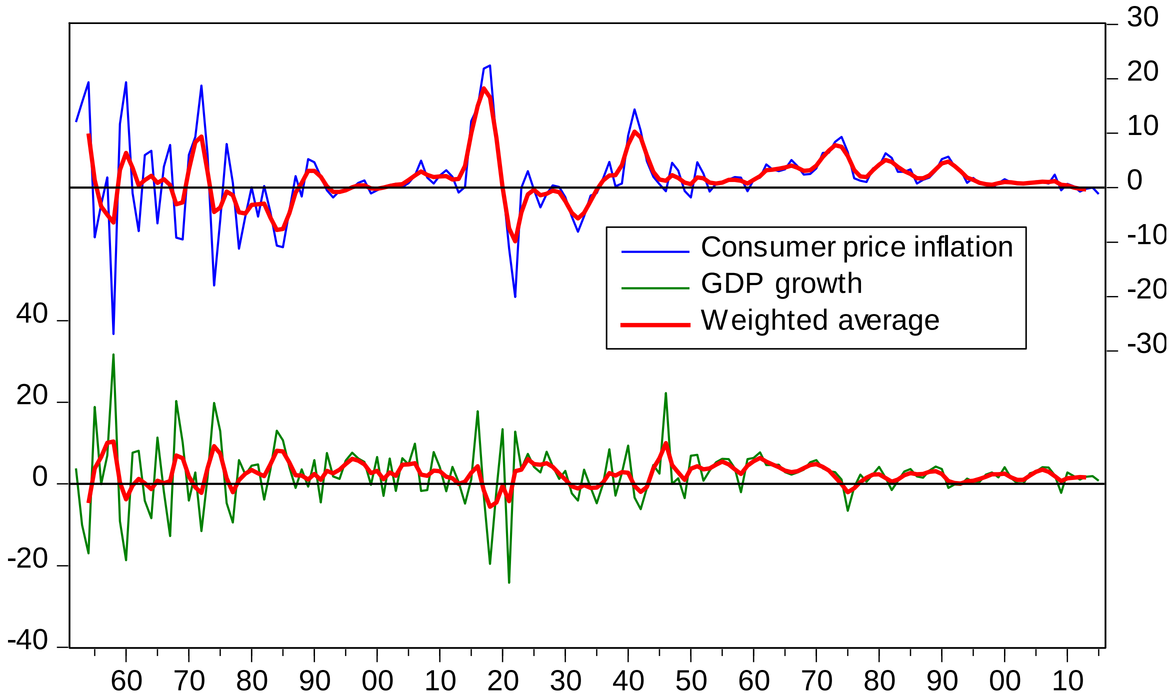

Figure 3: Accumulated impulse responses to aggregate demand and supply shocks with 95% confidence bands

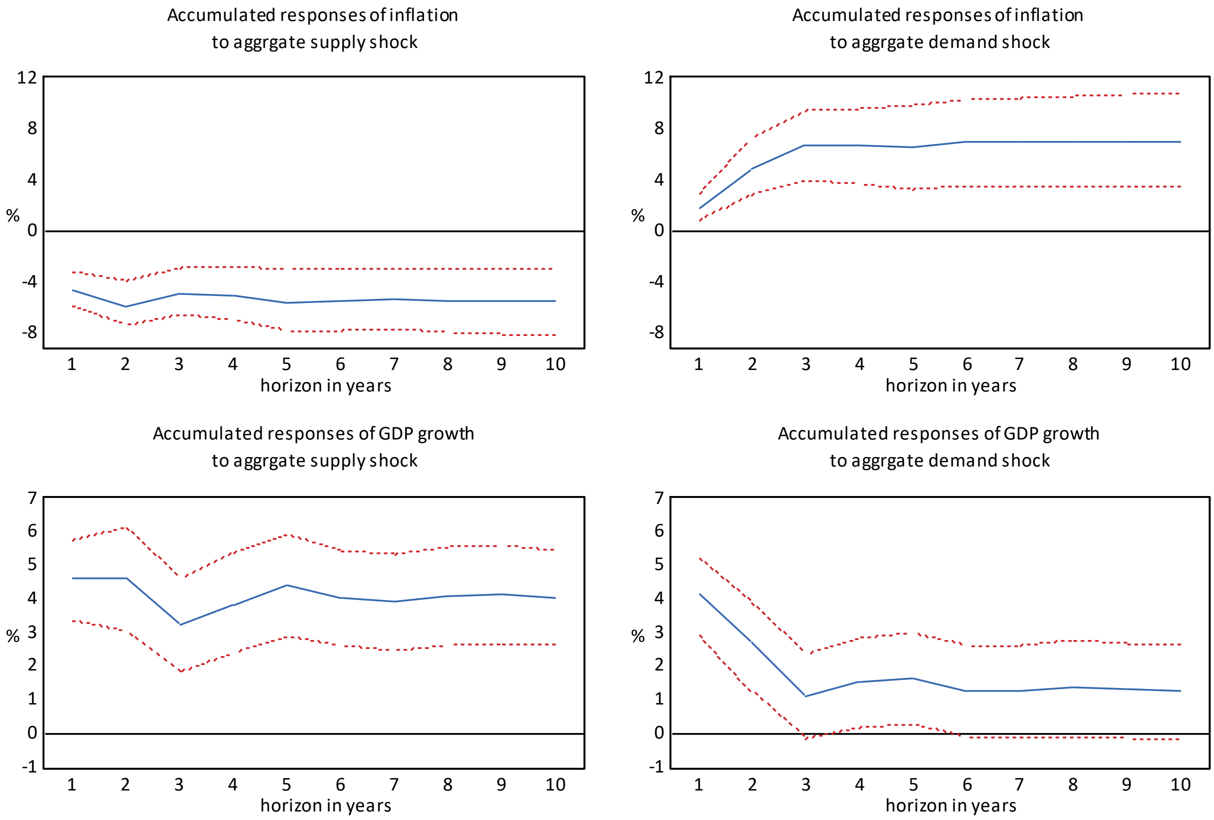

Figure 4: Estimated and weighted average aggregate supply shock

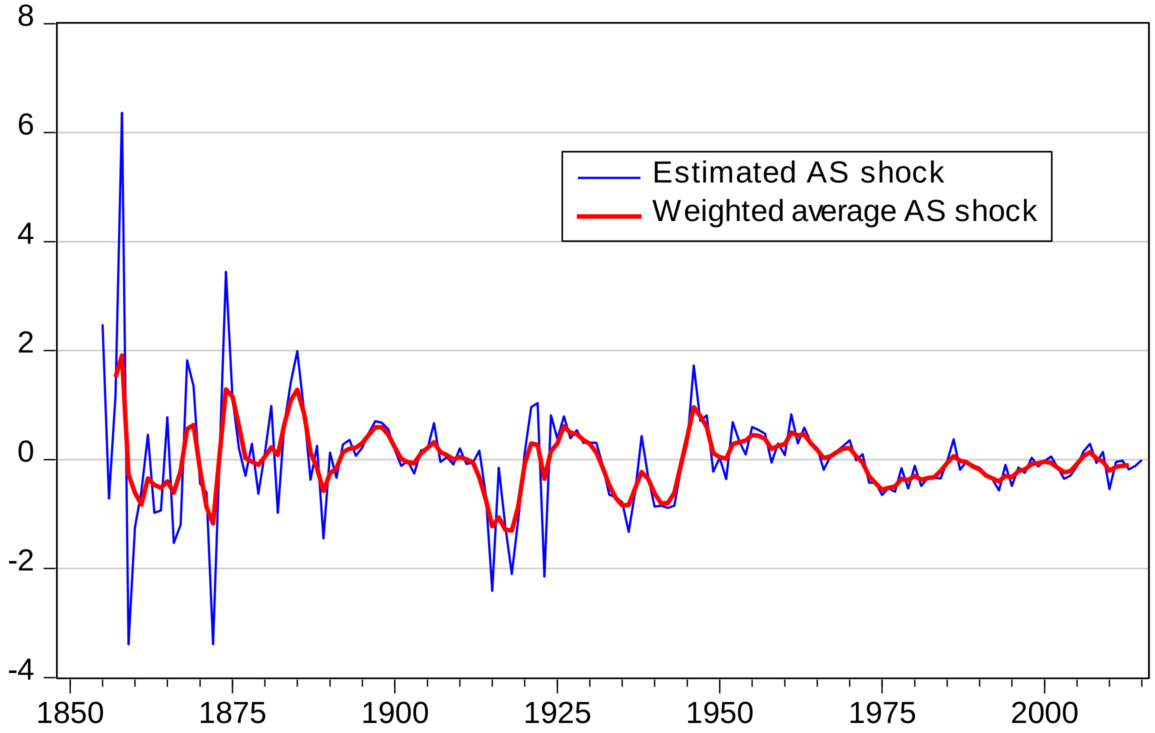

Figure 5: Estimated and weighted average aggregate demand shocks

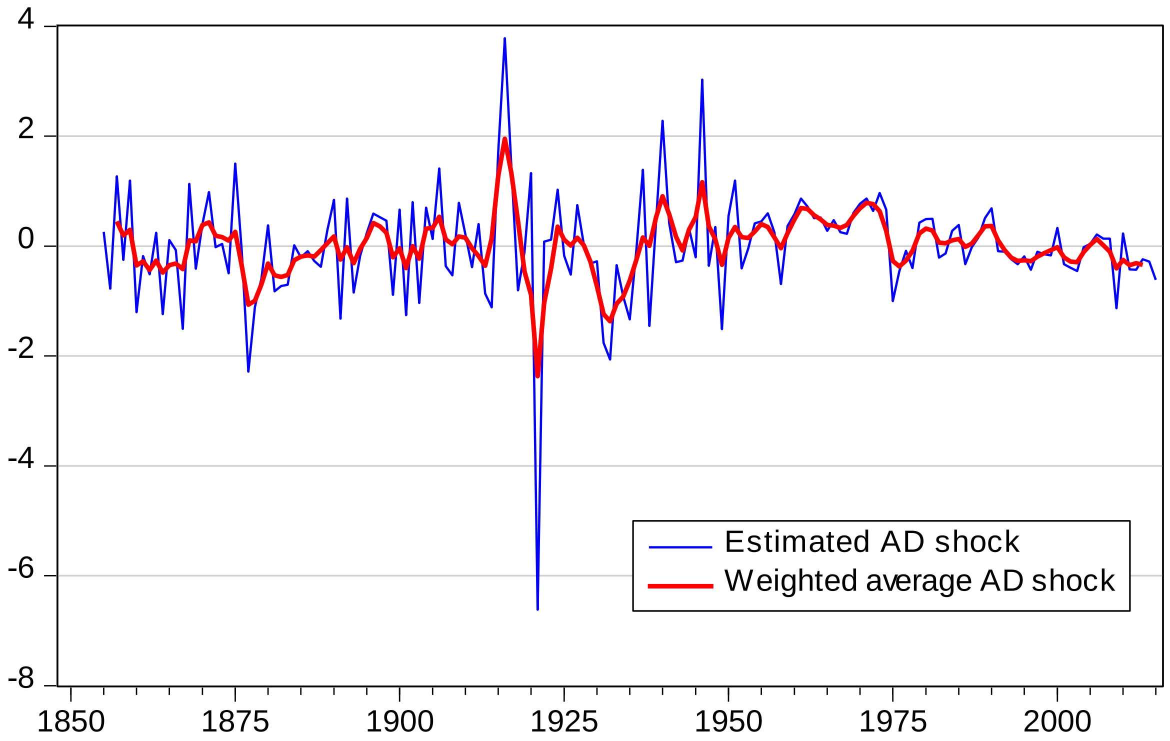

Figure 6: Variance decompositions, 1855-2015

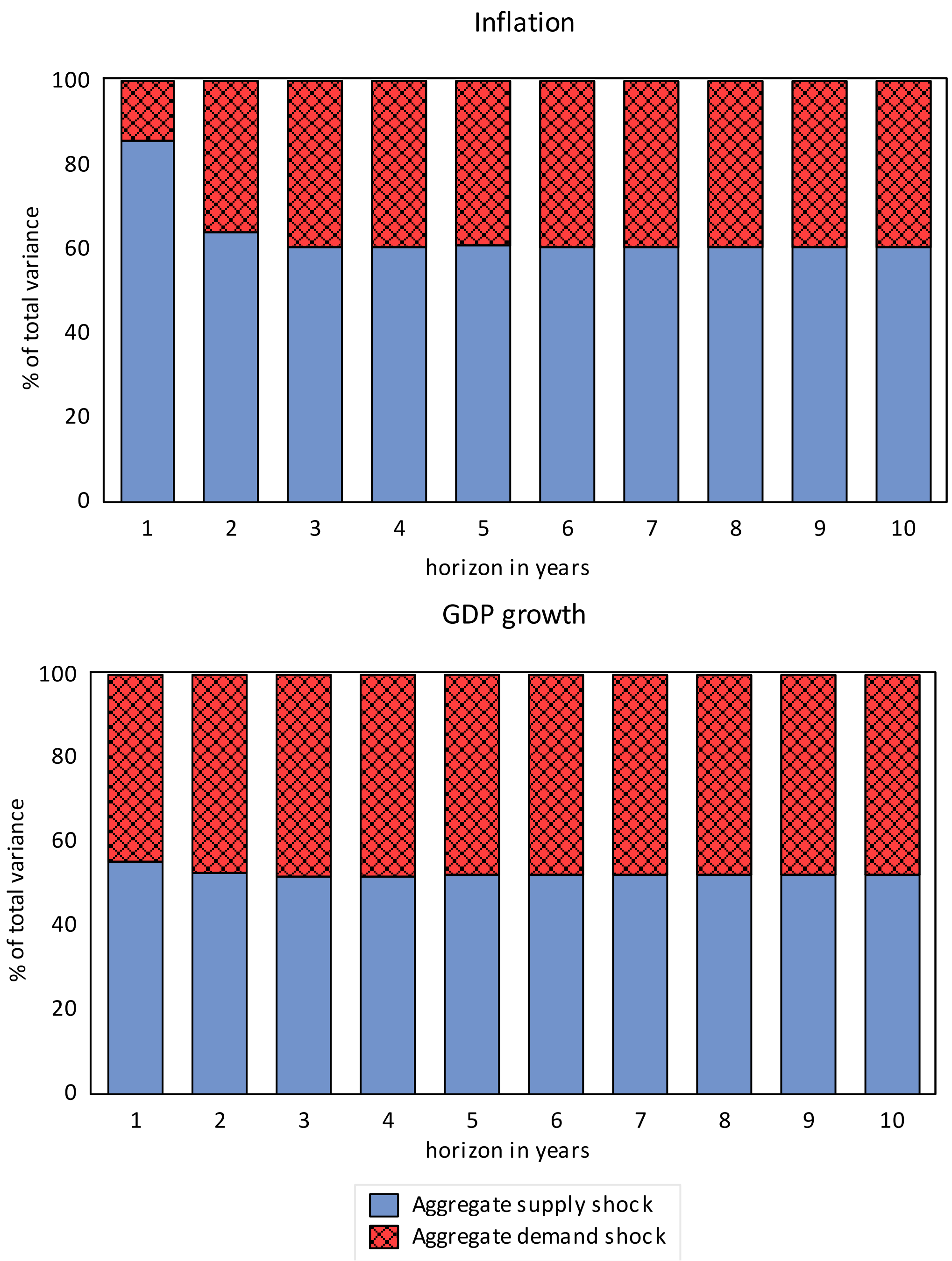

Figure 7: Historical decomposition of inflation, 1855-2015

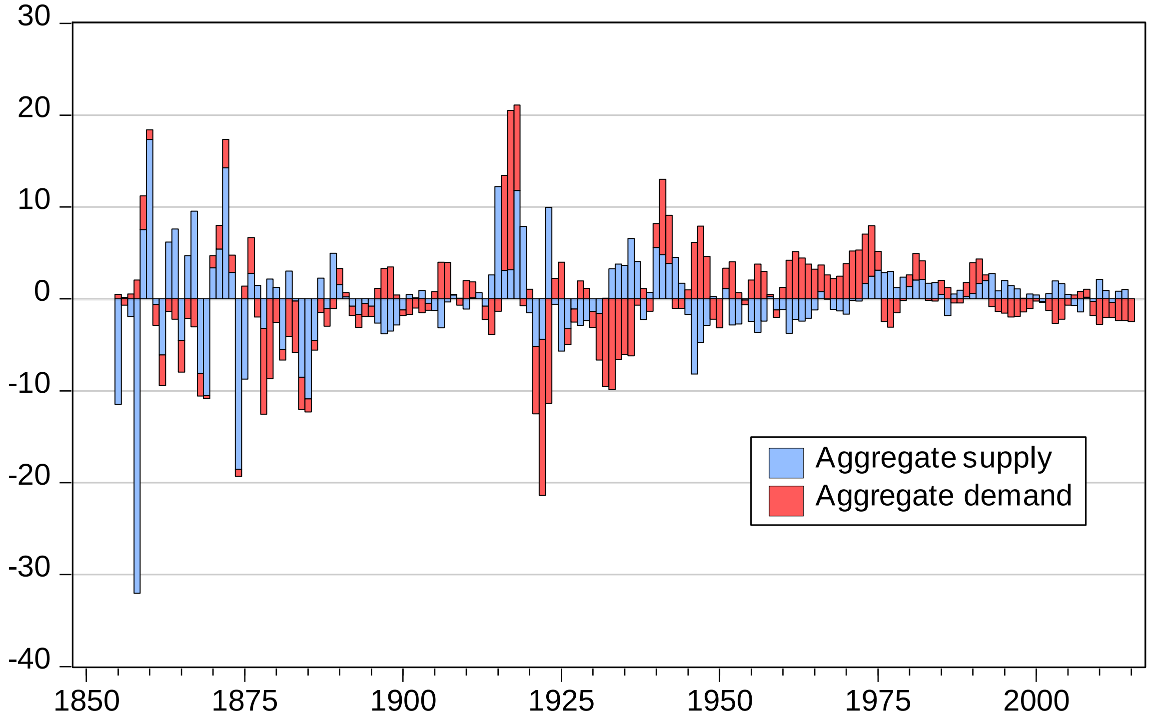

Figure 8: Historical decomposition of real GDP growth, 1855-2015

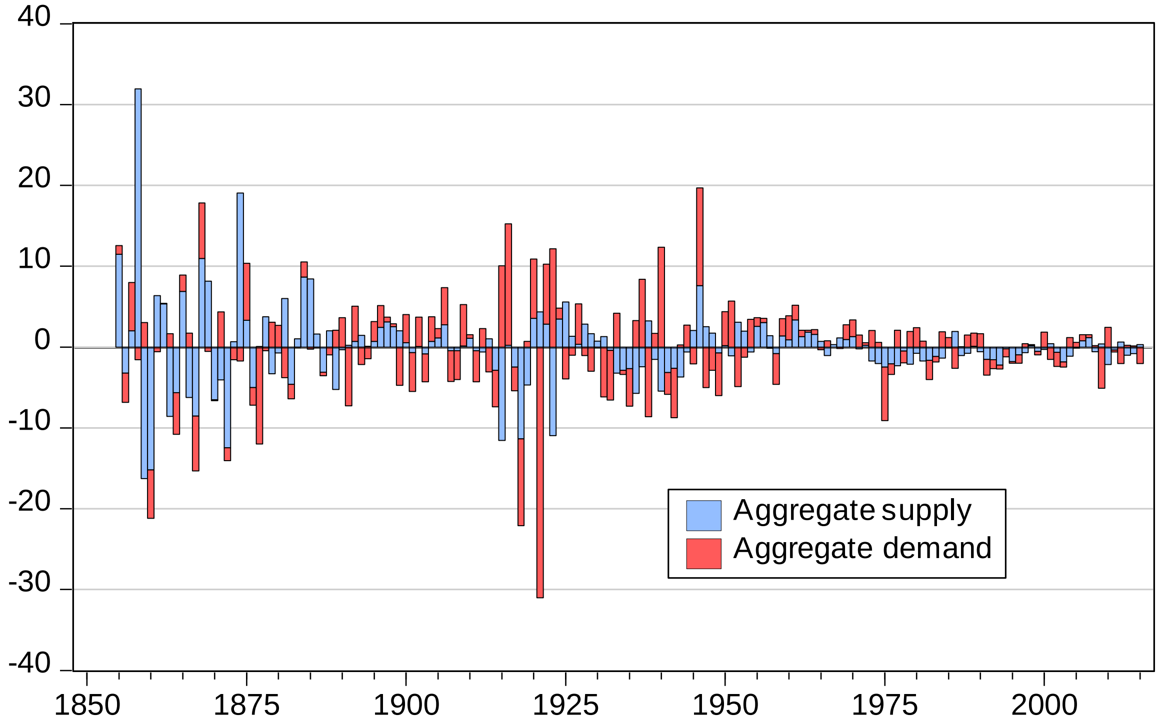

Figure 9: Residuals from single equation regressions

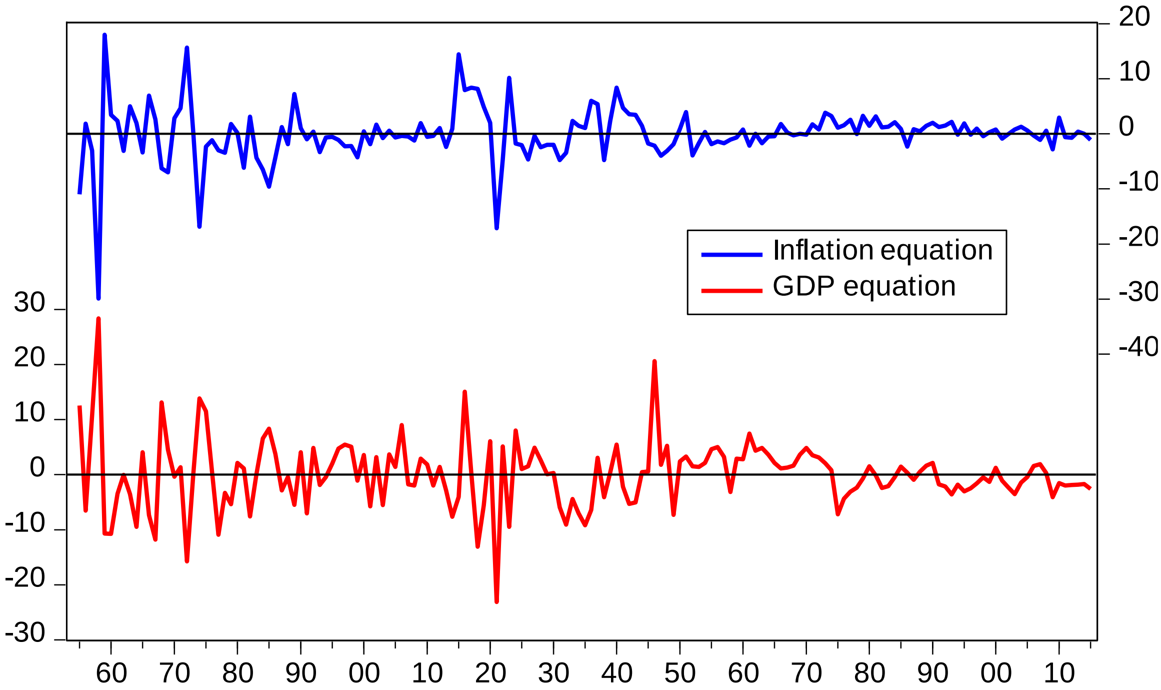

Figure 10: Aggregate supply and demand shocks, subperiod and full sample estimates

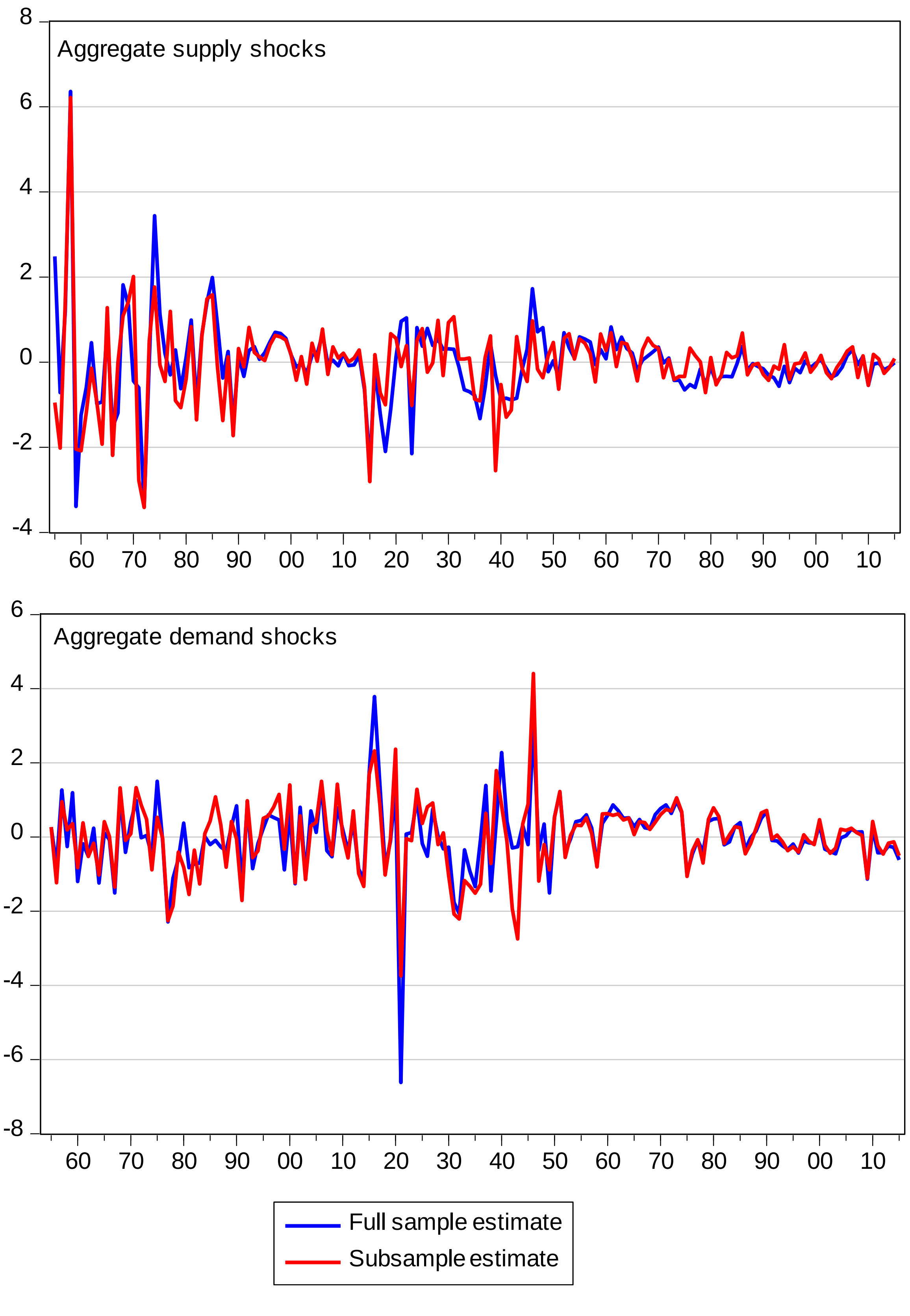

Figure 11: Aggregate supply and demand shocks under varying assumptions of price elasticity of demand (PED)

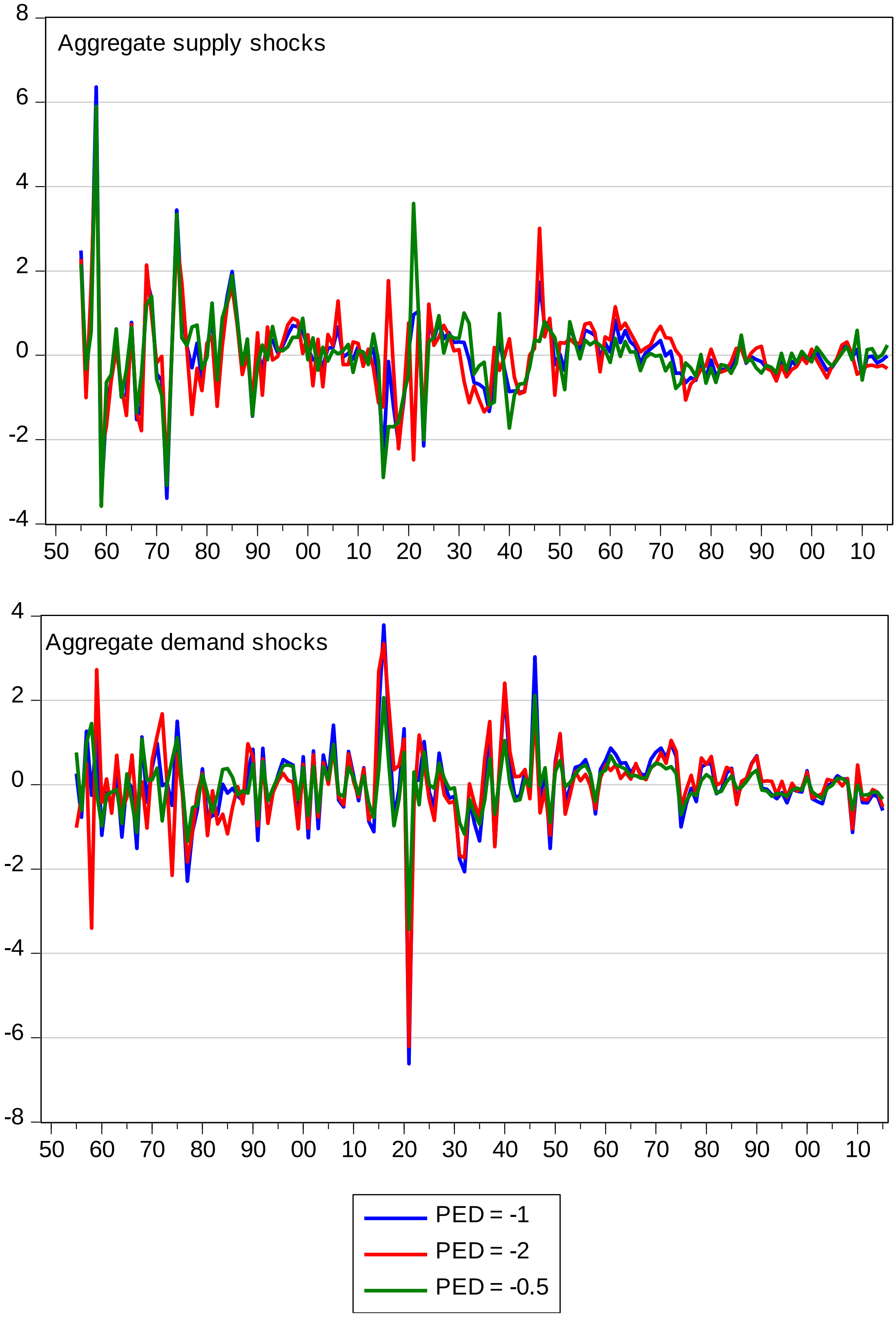

Figure 12: Aggregate supply and demand shocks using alternative output and inflation data provided in Stohr (2016)