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Is deflation depressing?
Evidence from the Classical Gold Standard

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Introduction

In the four decades before World War I most of the countries in the world adhered to the classical gold standard. The period was characterized by two decades of secular deflation, followed by two decades of secular inflation. This early price level experience should be of great contemporary interest because most advanced countries have returned to an environment of price stability not terribly dissimilar to that of the classical gold standard era.[1]

Deflation has had a 'bad rap'. Possibly as a consequence of the combination of deflation and depression in the 1930s, deflation is associated with (for some, connotes) depression. On the face of it, the evidence from the late 19th century was mixed: on the one hand, the mild deflation in the period 1870 - 1896 was accompanied by positive growth in many countries, however, growth accelerated during the period of inflation after 1896. We distinguish between good and bad deflations. In the former case, falling prices may be caused by aggregate supply (possibly driven by technology advances) increasing more rapidly than aggregate demand. In the latter case, declines in aggregate demand outpace any expansion in aggregate supply. This was the experience in the Great Depression (1929-33), the recession of 1919-21, and may be the case in Japan today.

In this paper we focus on the price level and growth experience of the United States and Canada, 1870-1913. Both countries adhered to the international gold standard, under which the world price level was determined by the demand and supply of monetary gold, and each member followed the rule of maintaining convertibility of its national currency into a fixed weight of gold.[2] This meant that the domestic price level was largely determined by international (exogenous) forces. In addition, neither country had a central bank which could intervene in the gold market to shield the domestic economy from external conditions.[3] While both countries had relatively similar resource endowments, the US was much more developed than Canada and hence was more exposed to the business cycle. In addition the US unit banking system was more prone to panics

[1] This is not to say that monetary authorities adhere to the principle of gold convertibility but that they are dedicated to low inflation or price stability.
[2] This is a slight simplification. The US suspended the gold standard during the Civil War, and only returned to convertibility in January 1879.
[3] The central banks of the core countries of Western Europe did have some limited flexibility to provide some insulation. Bordo and MacDonald (1997).

than its Canadian branch banking counterpart.[4] The experiences of the two countries, with their similar base money arrangements, yet different economic structures and institutions, add two more data points to the slim quantitative history of deflation, and further evidence on the significance of the distinction between good and bad deflation.

Table 1 and Figures 1 and 2 illustrate the macroeconomic performance of the US and Canadian economies over the period 1870 - 1914. Table 1 splits the period 1870 to 1896 in 1880, because of the distinct difference in the U.S. growth experience before and after 1880. The 1870s, saw rapid growth accompanied by fairly significant deflation. In the remainder of the period to 1896 growth slowed as did deflation - although price levels continued to fall. In the period after 1896, prices rose at roughly 2% and the growth rate of GDP (and per capita GDP) rose above that of the 1880s-early 90s, although it remained off the blistering pace of the 1870s.

In Canada, prices fell by about 0.4% p.a. to 1896 and subsequently rose secularly at about 2%. Real GDP grew at 2.4% during the deflationary period and rose by 6.5% from 1896 to 1913. A considerable part of the economic growth in the latter period was extensive growth coming from immigration but the change in the growth rate of real per capita GDP between the two periods was still stark - 1% in the first period, 4.3% in the latter.

For both historians and macro economists this period is a teaser. For macro economists the period provides a rare opportunity to study a secular deflation. For historians the causes of both the underperformance of the economy in the early years and the boom in the second half of the period are somewhat puzzling. For both groups the fundamental question concerns the relationship between the real and the nominal performance of the economy. Was there causation or merely correlation? In this paper we use time-series statistical methods to try to determine - albeit at a very aggregate level - the answer to this question.

We proceed by identifying separate ‘supply’ shocks, money supply shocks and demand shocks using a Blanchard-Quah methodology. We model the economy as a small open economy on the gold standard and identify the shocks by imposing long run restrictions on the impact of the

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[4] See Bordo, Redish and Rockoff (1994).

shocks on output and prices. We then do a historical decomposition to examine the impact of each shock on output. The results for the US are clear: the different rates of change in price levels before and after 1896 are attributed to different monetary shocks, but these shocks explain very little of output growth or volatility, which is almost entirely a response to 'supply' shocks. For Canada the results are murkier. As in the U.S., the money supply shocks before 1896 are predominantly negative and after that are largely positive. However, they are non-neutral, and relative to the US, money supply shocks play a larger role in determining output behaviour in Canada. We discuss possible explanations for this.

We begin by providing a brief historical context for the analysis, and then discuss the underlying theoretical model and empirical strategy that we follow. We then discuss the estimation results for the US and Canada. We conclude by integrating the somewhat contrasting results for the two countries.

Historical context

The US economy expanded rapidly in the early years after the Civil War, and the 1880s saw both the development of heavy industry in the East and rapid settlement of the West. It was the period of massive expansion of a transcontinental railroad network. Yet, this growth was accompanied by severe cyclical downturns in the post civil war era most of which were associated with banking panics and financial crises, 1873, 1893 and 1907 being the most severe. The net effect was that real GNP per capita was only 5% higher in 1896 than in 1880.

Williamson (1974) provides a detailed analysis of this period. He argues that the deceleration in economic growth until the mid 1890s, primarily reflected traditional Neoclassical forces: a high savings rate put the economy on a transition path to a new steady state, and along the transition path, capital accumulated, the return to capital fell, and the growth rate of income declined. His is a purely real model, and he concludes (p. 116) that since the quantitative predictions of his model capture the behaviour of the economy, monetary factors were not important in the growth slowdown.[5] One view of our paper is that it tests this result in an empirical model with a monetary side.

Growth accelerated after 1896. There were dramatic technological changes in goods production and equally so in the organization of firms and the economy. Industrialization and urbanization both changed the face of the economy. Yet even in these good years there were major downturns, and real per capita income fell in 5 different years between 1896 and 1914: 1903, 1907-8, and 1913-14.

In 1870 incomes per capita in Canada were about two thirds those in the United States. By 1880 the fraction had fallen to one half. But from 1880 to 1914, Canadian economic performance – at least by the measure of per capita income growth – outshone that of the US, although the US was still starkly ahead in levels.[6] As in the US, there were significant cyclical fluctuations embedded in the secular trends. In eleven of the 20 years from 1875 to 1895 per capita real incomes fell, despite the overall increase across the subperiod.

Canada experienced a short-lived boom after Confederation which ended in 1873. The stark contrast with US economic performance in the mid-1870s led to a migration of Canadians into the northern States (Inwood and Irwin, 2000) and the imposition of the National Policy tariff in an attempt to protect potential infant industries. The impact of that tariff is debated: certainly per capita incomes rose, but it was not until the mid-1890s that the economy flourished. Data on wages and unemployment are notoriously sparse, what little we have suggests that unemployment rose in the mid-1870s and, after relatively better performance in the end of that decade, was again high in the late 1880s. Nominal wages fell from 1888 to 1890 and remained flat in the 1890s.[7]

From 1896 to 1913, a period known to Canadians as the Wheat Boom, there was massive migration into Canada (primarily from Europe), rapid settlement of the Canadian West, and especially after 1907, very large foreign capital inflows. The relationship between the acceleration

[5] He does not explain the pick up in growth after 1896, and suggests that it remains a puzzle.
[6] In 1880 Canada and the US had the same gold parity and therefore an exchange rate of 1 between the two currencies. In 1870 the US dollar was valued at approximately C$ 0.75 as a result of the suspension of gold convertibility during and after the Civil War.
[7] Olley (nd) Table 27 and Table 10.

of intensive growth (rising per capita incomes) and that of extensive growth (increasing population) has been hotly debated amongst Canadian economic historians. In particular, research has focused on whether or not there was a mechanism that explains how the increasing population (assumed to be driven by the new availability of land) can explain the rising per capita income, given that the rise in the value of farms seems insufficient to explain the gains.[8]

Both Canada and the US (after the resumption of convertibility in 1879) were on the gold standard and so were similarly affected by the world monetary market. In the 1870s Germany and France (effectively) joined the gold standard and by 1879 the US had resumed convertibility of the Greenback. Gold stocks, however, were largely stagnant in the face of this increase in demand for gold, requiring that prices fall. Figure 3 shows that annual gold production averaged about 6 million ounces from 1870-1893. Gold discoveries in South Africa, and to a lesser extent in Australia and the Klondike, led to dramatically higher levels of gold production after 1893.

Figure 2a shows the behaviour of price indices for US and Canada. Deflation averaged only 1.2% p.a. in the US and less than 1% in Canada between 1870 and 1896, but the cumulative effect over more than two decades was a fall in the price level fell of 37% in the US and 21% in Canada. This situation was reversed after 1896 when gold discoveries increased the global stock of gold and therefore national money stocks, and prices rose worldwide. Secular deflation was replaced by secular inflation in both Canada and the US.

While both Canada and the US had monetary systems based on gold, the ‘inside’ money component of the money supply was produced under very different arrangements in the two countries. In Canada, a branch banking system was permitted to issue bank notes secured by the general assets of the bank, subject only to the limit that the quantity of notes not exceed the paid-in capital. As a matter of practice the banks often held significant money at call in New York, which they looked on as ‘secondary reserves’. In the US, the National banking system established in 1864 mandated that bank notes be (111%) secured by Federal government bonds and created a tiering of reserves.[9] Thus the US banking system had difficulty dealing with the seasonal

[8] The seminal article is Chambers and Gordon (1966). For a summary of the debate see Norrie and Owram (1996).
[9] Country banks had to hold 15% of the value of their deposits on reserve (of which 60% could be a deposit at a reserve city bank); reserve city banks had to hold 25% reserves (of which 50% could be a deposit at a central

fluctuations in the demand for money, and the New York money market acted as the central reserve for both countries.

Theoretical perspective

The fundamental question we are trying to resolve is the role of aggregate demand relative to aggregate supply shocks in output behaviour over the period. In the context of a simple supply-demand model, if the short run aggregate supply curve is vertical, then demand shocks will have no impact even in the short run, and the pattern of output growth would have been entirely driven by supply shocks. If the aggregate supply curve is upward sloping (for some time horizon) demand shocks would have an impact on output, and the deflation/stagnation followed by inflation/growth, may reflect demand shocks.

Earlier studies have applied a bivariate Blanchard-Quah methodology to gold standard economies, typically in contrasting gold standard and Bretton Woods regimes (for example, Bordo (1993), Keating and Nye (1998) and Bayoumi and Eichengreen (1995)). These studies used data on prices and output and identified a 'supply' shock as the innovation that has a permanent impact on output. An aggregate supply/aggregate demand model would predict that a positive supply shock would lower prices, however, in all three studies the estimated 'supply' shocks had a permanent positive effect on prices, the opposite of the theoretically predicted effect.[10] One explanation proposed for this - but not explicitly tested - is that the dominant supply shock is a terms of trade effect, which raises both output and prices. Figure 2b graphs the price level and the terms of trade for Canada and provides casual evidence that the price level and terms of trade are uncorrelated.[11] Furthermore, the terms of trade are improving during the 1871-1896 period when prices and output in Canada are falling and then stagnate while prices and output rise rapidly at the beginning of the twentieth century. When we included a terms of trade variable in the estimation of the traditional model it was insignificant and did not eliminate the perverse price effect of the estimated 'supply' shock. The 'supply' shock estimated in the bivariate model must

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reserve city bank); central reserve cities – New York, Chicago, and St. Louis – had to hold 25% reserves. Goodhart (1969; 16).

[10] The positive effect is also found on impact.

[11] The contemporaneous correlation is -0.24 and the correlation is smaller at 1 or 2 leads or lags. Terms of trade data are from Dick and Floyd (1992) Table B.3.

confound a demand shock that has permanent positive effects on prices and output with a true 'supply' shock.[12]

We propose an alternative identification scheme that is consistent with a standard monetary model for a small open economy on the gold standard.[13] We model the behaviour of output, prices and the money stock and identify three stochastic disturbances by assuming that the demand disturbance has no long run impact on either prices or output and the domestic supply shock has no long run impact on the price level. Implicitly, we are assuming that in the long run the domestic price level was tied down by the world price level (through monetary flows). Let Y represent real GDP, P the price level and M the money stock, and let e_s be the 'supply' shock, e_{ms} the money supply shock, and e_d a demand (that is, demand other than money supply) shock. Then, if the matrix A(1) represents the long run multiplier matrix where each element $a_{ij}(1)$ captures the long run effect of shock j on variable i, we can write,

$$\begin{bmatrix} \Delta P \\ \Delta Y \\ \Delta M \end{bmatrix} = \begin{bmatrix} a_{11}(1) & 0 & 0 \\ a_{21}(1) & a_{22}(1) & 0 \\ a_{31}(1) & a_{32}(1) & a_{33}(1) \end{bmatrix} \begin{bmatrix} e_{ms} \\ e_s \\ e_d \end{bmatrix}$$

The identification of the demand shock is uncontroversial, but the critical assumption here is that 'supply' shocks do not affect the price level in the long run. Here we rely on the small open economy assumption under which the domestic economy takes the price level as exogenous. We assume that the supply shock captures supply shocks that were specific to the domestic economy – and did not have an effect on the world price level *in the long run.* (Importantly we find the restriction is not a binding one for the US economy - a result consistent with Bayoumi and Eichengreen who find a horizontal aggregate demand curve.) Since the major determinant of world prices over our period was the changing world production of gold, we refer to the shock

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[12] See Calomiris and Hanes (1994) for an extended discussion of the sources of persistence from demand shocks.

[13] Our identification strategy is similar to that of Dupasquier, Lalonde and St.-Amant (1997). They use a tri-variate Blanchard and Quah decomposition with the same ordering to identify monetary, supply and non-monetary demand shocks for the post-Bretton Woods period, but use interest rates rather than the money stock (and assume that the price level is I(2)).

that has a long run impact on prices as the money supply shock.[14] Using this identification of supply and money supply shocks we can measure separately the effect of each on output.

The third shock captures impulses that have no permanent effect on prices or output. In the context of a small open economy on the gold standard these are essentially IS demand shocks, or money demand shocks, and they cannot be disentangled in this empirical specification. If IS shocks dominate, the impact effect of the shock on all three variables will be positive, and it will have no long run effect on the money stock. If money demand shocks dominate then prices and output will fall on impact and there will be a permanent increase in the money stock.

The restrictions imply that A(1) is lower triangular, and by imposing the restrictions and the assumption that the three shocks are orthogonal, we can estimate the parameters of A(L) - the impulse response functions - and identify the structural innovations.[15] The key to the validity of this methodology is that the identifying restrictions indeed identify objects consistent with the theoretical model. The usual way to test this is to look at the overidentifying restrictions. That is, theory has implications for the long-run and short-run impacts of each shock on each variable. Our basic framework is the Cambridge money demand equation with stochastic money demand shocks, applied to a small open economy on a gold standard. A positive money supply shock is defined as one that raises the money stock in the long run, and it is predicted to increase each of the three variables on impact. If money were neutral, the money shock would cause equal (proportionate) increases in the money stock and prices in the long run with no effect on output. A positive supply shock is one that raises output in the long run, and would lead to an endogenous, long run increase in the money stock. The model predicts that in the short run prices would fall and the money stock would rise. Finally, the demand shock is defined as one that causes an increase in the money stock, and its short run impact is indeterminate as discussed above.

There are 18 combined impact and long run responses to the shocks. Table 2 summarizes the predicted effects and indicates whether the restriction was imposed, used as a normalization or can be used as an overidentifying restriction. If the estimated impulse response functions are

[14] The money supply shock could equally be viewed as a world price level shock.

consistent with these over identifying restrictions then we can be relatively confident that the estimated shocks are consistent with the innovations in the model.

Having estimated the matrices A(L) and the innovations e_t we can examine the behaviour of each of the shocks (the variance of each shock is normalized to 1). The impact of the various shocks can be measured by a forecast error variable decomposition, which measures the contribution of each type of shock to forecast errors at various horizons, and most importantly for our purposes we can measure the effect at each point of historical time of each kind of shock. For example, we can decompose the growth rate of output in 1880 say into (1) the effect of shocks that occurred before 1873 - the start of the sample - and are having continued effects, and (2) the effect of each of the shocks since 1873. The effects of supply shocks, for example, are computed by taking the supply shock for each period from 1873 to 1880 and multiplying it by the impulse response parameter for the number of periods between the occurrence of the shock and 1880.

We use this method of historical decompositions to identify the role of 'supply' shocks, money supply shocks and money demand shocks on the levels of output, prices and money in the US and Canada from 1873 and 1914.

There are of course, other approaches that could and have been taken to determine the role of monetary factors in this period. An approach that is similar would involve estimating a VAR that incorporated a co-integrated money demand function. The advantage of this approach is that by imposing the structure of a money demand function, one can get tighter parameter estimates. However, there are major disadvantages. Essentially, it requires the existence of a stable money demand function, for which the evidence is weak at best.[16] For Canada this may be because of the absence of interest rate data, or because of more fundamental money demand instability.

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[15] See Clarida and Gali (1995). The method is briefly described in the Appendix.

[16] Johansen and Juselius estimation methods reject a co-integration relationship between money, prices and income for Canada, although Engle and Granger single equation methods do not. The former is however the more powerful technique, and the one that is appropriate for the multivariate context - i.e. one where money, prices and output may all respond to deviations from the long run relationship.

Empirical Analysis - United States

Figure 4 presents the impulse responses for the US.[17] The graphs show the cumulative effect, at every point of time, on each variable, of an isolated shock at time '0'. Thus the upper graphs shows that an average positive money supply shock caused prices to rise on impact, to rise somewhat further in the next year or two and to stay at that higher level. The lowest graph shows that the money stock itself behaved very similarly, while the middle graph shows that the money supply shock caused output to rise on impact, but that after the first 2 years output was back at its initial level. These results show money to be non-neutral in the short run, and (roughly) neutral in the long run. Importantly, this long run neutrality is not imposed.[18]

The supply shock causes a positive and permanent increase in the level of output, and after the first year, to the quantity of money. That is, the quantity of money responds endogenously to the increases in output, with an elasticity of approximately one half. The supply shock causes a fall in the price level - although probably insignificantly – and after the first period, the price level returns to its previous level.

The demand shock leads to a permanent increase in the money stock and a (very) temporary decrease in prices. These results are consistent with the interpretation of the demand shock as a money demand innovation, but the demand shock also causes an increase in output which is not consistent with such an interpretation. As noted above, the model does not have sufficient restrictions to enable us to identify the demand shock, other than as a compound of the temporary disturbances to output.

While impulse response functions indicate the impact of an isolated shock over time on each variable, since their variance is normalized to unity, they do not measure the relative importance of the shocks. A forecast error variance decomposition (FEVD) combines the information in the variances of the shocks and the impulse responses, and so describes their relative contribu-

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[17] The money supply data and output data are found to be unambigously I(1) in pre-testing. The characteristics of the price level are more ambiguous with the order of integration (0 vs. 1) depending on the lag length selection criterion, and unit root test used. The unrestricted VAR is estimated with 2 lags.

[18] The *imposed* restrictions are that the supply shock does not affect prices in the long run, and that the demand shock only affects the stock of money in the long run.

tions. The FEVD are presented in Table 3, and can be interpreted as follows: Take the 2 year ahead decomposition of the forecast error for output. If one were trying to forecast output 2 years ahead, one would on average make an error that depends on the size of the three (definitionally unobservable) shocks in each future year, their usual impact on the variable and their persistence. In an extreme case supply shocks might have a permanent impact while money supply shocks have only a one year influence. Thus the two year ahead forecast would reflect two years worth of supply shocks but only one year of money supply shocks.

Largely by assumption, at the five year horizon forecast errors for the price level primarily arise from money supply shocks. However, output is mostly driven by 'supply' shocks. The money stock is driven by shocks to both demand and the money supply. The estimated structural innovations themselves are illustrated in Figure 5. Again, since they are normalized to have a variance of unity, their absolute size has no interpretation. There is a run of negative money supply shocks in the early 1890s followed by a run of positive shocks after 1896. In the last decade of the sample there was a string of negative demand shocks.

The historical decompositions are illustrated in Figures 6-8. We are particularly interested in output, shown in the three panels of Figure 7. In each of the three panels, two curves are reproduced – the actual growth rate of income, and the base case, which comprises trend growth plus the lingering effects of shocks that occur before the start date. The third curve shows the sum of the base case plus the effect of one particular shock. For example, the top graph in Figure 7 the 3rd curve shows how (according to the model) output growth would have evolved if there had been no supply or demand shock, isolating the impact of the money supply shock on output growth. The fact that this curve is, particularly after 1890, not very different from the base case, shows that the money supply shock did not drive output growth. Similarly, the fact that in the middle panel the 3rd line is very close to the 'actual' line implies that the supply shock explains most of output growth. (Non-monetary) demand shocks, in the lowest panel, were nontrivial, but much less important than the supply shocks.

The historical decomposition of the price level (Figure 6) tells a parallel story. The price level was very largely determined by the money supply shocks, while supply shocks (and again to a lesser extent non-monetary demand shocks) were not important drivers of prices. The money stock reflected both money supply and money demand shocks, but not supply shocks. This latter effect is a reflection of the low income elasticity of money demand seen in the impulse responses (compare the impact of supply shocks on output and the money stock in the bottom 2 panels of Figure 4).

The interpretation of behaviour in the US over the period is fairly straightforward: positive (negative) money supply shocks explain the behaviour of the price level, and did have temporary positive (negative) effects on output. However, apart from the volatility between 1877 and 1887, money supply shocks had only a small impact on output, and do not explain the trends in output growth.

Empirical Analysis - Canada

Figure 9 shows the estimated impulse response functions for Canada.[19] As in the US case, the money supply shock is estimated to cause an increase in prices and the level of the money stock but, unlike in the US, money is not neutral in the long run. We find a persistent positive effect on output from a positive money supply shock. We return to this surprising result below.[20] The supply shock has the expected positive effect on the level of output and the stock of money, and again the elasticity of money demand is approximately one half. The price level falls on impact of the supply shock, and quickly returns to its initial level. The demand shock has its major impact on the money stock, with a small temporary positive impact on output and prices.

The forecast error variance decomposition results (Table 4) show that supply shocks explain most of the forecast error variance for output. The forecast error variance of prices is explained by money supply shocks at all horizons, while both money supply and demand shocks have a significant impact the money. Figure 10 shows the estimated structural innovations over time. As in the US, money supply shocks were predominantly negative in the pre 1896 period, and then positive in the post 1896 period. Perhaps surprisingly, supply shocks were positive from

[19] As for the US, the money stock and output series were found to be I(1) and the price data either I(1) or I(0) depending on the test. We estimate the model in first differences to be sure the data are stationary. For Canada lag length tests led us to use only first order terms in the unrestricted VAR.
[20] The result is robust to changes in specification such as lag length and use of alternative monetary aggregates.

1876 to 1883 with the exception of 1880. The decade from 1884 to 1895 however saw a run on negative supply shocks.

The historical decompositions for Canada are in Figures 11-13. Again for each variable, we present three panels. In each panel the behaviour of the growth rate of the variable over time and the 'base case' (trend growth) are depicted as well as a line illustrating the base case plus the effect (contemporaneous plus lagged) of one of the shocks. Again beginning with the decomposition of output in Figure 12, the similarity between the dashed line and the actual behaviour in the middle panel indicates that the behaviour of output was driven very much by the supply shocks. The upper and lower panels show that both money supply shocks and demand shocks affected output (their dashed lines deviate from the almost horizontal base case), but do not play as major a role as the supply shocks. In Figure 11, we see that the money supply shocks do explain price behaviour.[21] Finally, Figure 13 suggests that money supply shocks and demand shocks were the major forces driving the evolution of the Canadian money stock. The supply shock did cause some of the variation in the growth rate of the money stock, as that stock responded to changes in money demand coming from changing income, but the other factors were larger influences.

Overall, in Canada as in the US, we find that the economy evolved in a relatively classical way. Exogenous changes in the money stock drove the behaviour of the price level, and 'supply' shocks drove the behaviour of output.

Discussion of results and conclusion

In the 1870s the gold standard became virtually universal, raising monetary gold demand with no significant increases in supply. Unsurprisingly the world price level fell. Gold discoveries in the 1890s caused the world gold stock to rise, and so did prices. In the US, and more so in Canada, the deflation was contemporaneous with slow economic growth, and the inflation with a booming economy. Was there a direct connection? Did monetary forces generate the bust and boom? We find that the connection was more coincidence than causation. The money supply

[21] In Figure 11 the base case and actual are very similar since the trend rate of inflation over the entire period was virtually zero.

shocks were large and explain most of the variation in the price level. Yet, in both the United States and Canada, they do not explain the behaviour of output. That behaviour was driven primarily by supply shocks.

An open question that our analysis has raised is the apparent non-neutrality of the money supply shocks in Canada, and why the Canadian responses are so different from those in the US. One possible answer would be that there were greater nominal rigidities in Canada, although it is difficulty to ascertain what those would have been. An alternative resolution relates to the differences between the banking systems in the two countries, and their possible consequences for the transmission of monetary shocks to the real economy. For example, the Canadian banking system had lower reserve ratios than that of the US, and proportionately more loans in their portfolios, implying that the credit channel may have been more significant leading to greater persistence of monetary shocks in Canada. This is obviously an area for future work, and in particular, we plan to expand the data set by including other gold standard countries, and use a panel approach that will give us more power to identify global monetary and technology shocks.

Finally, the fact that growth was lower in both countries during the deflation era, 1870-96, than during the subsequent period of inflation may be due to a different real environment but it could also be due to another set of issues which we do not explore in this paper, namely the relationship of deflation/inflation to growth via channels such as expectations formation and incomplete contracts, as in for example, Irving Fisher's debt deflation story. Again this is an area for future research. The key conclusion of our analysis is clear however. The simple demarcation of good vs bad deflation, where either prices fall because of a positive supply shock, or prices fall because of a negative demand (money) shock does not capture the complexity of the historical experience of the pre-1896 period. Indeed, we find that prices fell as a result of a combination of negative money supply shocks and positive supply shocks.

Table 1

Income Levels

	Real GNP (m$1971)		Real GNP pc ($1971)		Prices ($1971)	
	US	Canada	US	Canada	US	Canada
1870	33,540	2,071	865	573	22.7	18.5
1880	64,070	2,573	1275	606	18.2	18.5
1896	94,490	3,810	1332	753	14.6	16.7
1913	195,260	11,114	2008	1454.6	20.25	23.9

Income Growth Rates

	Real GNP (m$1971)		Real GNP pc ($1971)		Prices ($1971)	
	US	Canada	US	Canada	US	Canada
1870-80	6.7%	2.2%	3.9%	.5%	-1.8%	0
1880-96	2.5%	2.5%	.2%	1.3%	-1.1%	-0.5%
1870-96	4.1%	2.4%	1.6%	1%	-1.2%	-.36%
1896-13	4.4%	6.5%	2.4%	4.3%	1.9%	2.1%

Money Stock

	Growth of Stock		M pc		Growth of M pc	
	US	Canada	US	Canada	US	Canada
1870-80	4.2%	2.9%	$45.86	$20.72	1.8%	1.2%
1880-96	4.9%	5.3%	$54.87	$23.43	2.6%	4.1%
1870-96	4.6%	4.4%	$83.22	$44.70	2.3%	3.0%
1996-13	7.8%	9.7%	$219.55	$143.55	5.9%	7.1%

Sources: US data (except population) are all from Balke and Gordon, (1989); Canadian nominal GDP and population are from Urquhart (1993); Canadian prices are from Dick and Floyd (1992); Canadian money stock data are from Metcalf, Redish and Shearer (1998).

Table 2

Predicted Effects of Each Innovation

	On Output		*On Prices*		*On Money Stock*	
	Impact	Long run	Impact	Long run	Impact	Long run
Money supply	+	=	+	+	+	+(N)
Supply	+	+(N)	-	0(I)	+	+
Demand	?	0(I)	?	0(I)	+(N)	?

I indicates an identifying restriction; N represents a normalization – i.e. not an overidentifying restriction

Table 3: Forecast error variance decomposition: United States

Impact on FEVD for output of :			
Horizon	**Money Supply**	**Supply**	**Demand**
1	10.85	88.66	0.49
2	11.93	83.84	4.23
3	11.14	78.86	10.05
4	13.08	77.19	9.73
5	13.01	77.12	9.86
10	13.06	77.00	9.94

Impact on FEVD for prices of :			
Horizon	**Money Supply**	**Supply**	**Demand**
1	93.53	3.80	2.67
2	81.14	6.25	12.61
3	82.08	6.02	11.91
4	81.65	6.49	11.86
5	81.03	6.50	12.47
10	80.95	6.50	12.56

Impact on FEVD for money of :			
Horizon	**Money Supply**	**Supply**	**Demand**
1	42.06	14.00	43.94
2	46.41	9.94	43.65
3	47.27	10.08	42.65
4	47.25	10.19	42.57
5	47.23	10.08	42.69
10	47.33	10.04	42.63

Table 4: Forecast error variance decomposition: Canada

Impact on FEVD for output of :			
Horizon	**Money Supply**	**Supply**	**Demand**
1	16.20	81.86	1.93
2	16.01	77.98	6.00
3	17.45	75.98	6.57
4	17.66	75.71	6.62
5	17.81	75.57	6.62
10	17.87	75.51	6.62

Impact on FEVD for prices of :			
Horizon	**Money Supply**	**Supply**	**Demand**
1	83.97	13.25	2.78
2	84.30	11.68	4.02
3	85.23	10.88	3.89
4	85.52	10.66	3.82
5	85.65	10.58	3.78
10	85.71	10.53	3.75

Impact on FEVD for money of :			
Horizon	**Money Supply**	**Supply**	**Demand**
1	16.96	21.76	61.23
2	30.79	18.18	51.02
3	33.78	17.45	48.77
4	34.96	17.19	47.85
5	35.35	17.10	47.55
10	35.58	17.04	47.37

Appendix

Define a structural model:

$$\Delta X_t = A(L)e_t$$
$$= A_0 e_t + A_1 e_{t-1} + A_2 e_{t-2} + \ldots$$

The objective is to find the values of the A_i and e_t.

We begin by estimating a reduced form model

$$B(L)\Delta X_t = e_t$$

And invert the model to get its moving average representation

$$\Delta X_t = B(L)^{-1} e_t$$
$$= C(L)e_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + \ldots.$$

where by definition C_0=1

Let $E(e_t e_t') = \Sigma$ be the estimated reduced form variance covariance matrix, and note that $e_t = A_0 e_t$ and $C_1 e_{t-1} = A_1 e_{t-1}$ which together imply $A_1 = C_1 A_0$ and more generally $A_i = C_i A_0$.

Thus knowledge of A_0 combined with the estimated C_i and e_t will identify all A_i and e_t.

Assume that the structural innovations are orthogonal to each other and normalize them to have unit variance. Then, $E(e_t e_t') = I$. But since $E(e_t e_t') = \Sigma$, $E(A_0 e_t e_t' A_o') = \Sigma$ and therefore $A_0 A_0' = \Sigma$. Since there are only 6 independent variables in Σ, and nine elements in A_0, this relationship does not uniquely identify the elements of A_0. To do so we impose the restriction that A(1), the matrix of long run multipliers is lower triangular, as described in the text.

Define $C(1) = C_0 + C_1 + C_2 + \ldots$, where $C_0 = I$, and rewrite this as

$$C(1) = A_0 A_0^{-1} + A_1 A_0^{-1} + A_2 A_0^{-1} +$$
$$= A(1) A_0^{-1}$$

Form C(1) Ó C(1)' and find the Choleski decomposition of this which yields the unique lower triangular matrix H such that $C(1`)\Sigma C(1)' = HH'$. Note that $C(1)\Sigma C(1)' = A(1)A(1)'$, so that $H = A(1)$. Now we can find A_0 from $C(1) = A(1)A_0^{-1}$.

References

Balke, N. and R. Gordon, (1989) "The Estimation of Prewar Gross National Product Methodology and New Evidence" *Journal of Political Economy*, 97(1) February 38-92.

Bayoumi, T. and B. Eichengreen, (1995) "Déjà Vu All over again: Lessons from the gold standard for European Monetary Unification" in T. Bayoumi, B. Eichengreen and M. Taylor eds, *Modern Perspectives on the Gold Standard*, Cambridge: Cambridge University Press.

Bertram, G. and M. Percy, (1979) "Real Wage Trends in Canada, 1900-26: Some Provisional Estimates" *Canadian Journal of Economics*, 12(2) May, 299-312.

Blanchard, O. and O. Quah, (1989) "The Dynamic Effects of Aggregate Demand and Supply disturbances" *American Economic Review*, September, 655-673.

Bordo, M. (1993) "The Gold Standard, Bretton Woods and Other Monetary Regimes: A Historical Appraisal" in Federal Reserve Bank of St. Louis, *Review* March/April, 123-91.

Bordo, M. and R. MacDonald, (1997) "Violations of the Rules of the Game and the Credibility of the Classical Gold Standard" NBER Working Paper 6115.

Bordo, M., P. Rappoport and A. Schwartz (1992) "Money versus Credit Rationing: Evidence from the National Banking Era, 1880-1914" in C. Goldin and H. Rockoff eds. *Strategic Factors in Nineteenth Century American Economic History* Chicago: University of Chicago Press.

Bordo, M., A. Redish and H. Rockoff, (1994) "The US Banking System from a Northern Exposure: Stability vs. Efficiency" *Journal of Economic History* 54(2): 325-41.

Calomiris, C. and C. Hanes (1994) "Historical Macroeconomics and American macroeconomic history" NBER working paper 4935.

Chambers, E. and D. Gordon, (1966) "Primary Products and Economic Growth: An Empirical Measurement" *Journal of Political Economy* LXXIV 4: 315-32.

Clarida, R. and J. Gali, (1994) "Sources of Real Exchange-Rate Fluctuations: How Important are Nominal Shocks?" *Carnegie-Rochester Conference Series on Public Policy*, 41:1-56.

Dick, T. and J. Floyd, (1992) *Canada and the Gold Standard: Balance of Payments adjustment, 1871-1913* Cambridge: Cambridge University Press.

Dupasquier, C. R. Lalonde and P. St-Amant, (1997) "Optimum Currency Areas as Applied to Canada and the United States" in *Exchange Rates and Monetary Policy* Proceedings of a conference held by the Bank of Canada, October 1996.

Friedman, M. and A Schwartz, (1963) *A Monetary History of the United States, 1967-1960* Princeton: Princeton University Press.

Goodhart, C.A.E. (1969) *The New York Money Market and the Finance of Trade, 1900-1913* Cambridge, Mass.: Harvard University Press.

Gordon, R. (1986) *The American Business Cycle: Continuity and Change,* Chicago: University of Chicago Press.

Green, T. (1999) "Central Bank Gold Reserves: A historical perspective since 1845" World Gold Council Research Study No. 23.

Inwood, K. and J. Irwin, (2000) "The Patterns of Net Migration by Canadians during the Late Nineteenth Century". ms. University of Guelph.

Keating, J. and J. Nye, (1998) "Permanent and Transitory Shocks in Real Output: Estimates from Nineteenth-Century and Postwar Economies" *Journal of Money Credit and Banking* May: 231-51.

Metcalf, C., A. Redish and R. Shearer, (1998) "New Estimates of the Canadian Money Stock, 1871-1967", *Canadian Journal of Economics* February: 104-24.

Norrie, K. and D. Owram, (1996) *A History of the Canadian Economy*, Toronto: Harcourt Brace and Co.

Olley, R. (nd) Construction wage rates in Ontario, 1864-1903. Kingston.

Taylor, K. (1931) *Statistical Contributions to Canadian Economic History*, Vol. II Toronto: Macmillan.

Urquhart, M. (1993) *Gross National Product, Canada, 1870-1926, The Derivation of the Estimates* Montreal: McGill-Queens University Press.

United States Senate (1924) *Commission of Gold and Silver Inquiry* 67th Congress 4th Session Washington:GPO.

Williamson, J. (1974) *Late 19th century American development: a general equilibrium history*. New York: Cambridge University Press.

Figure 1a: Log real GDP, US and Canada

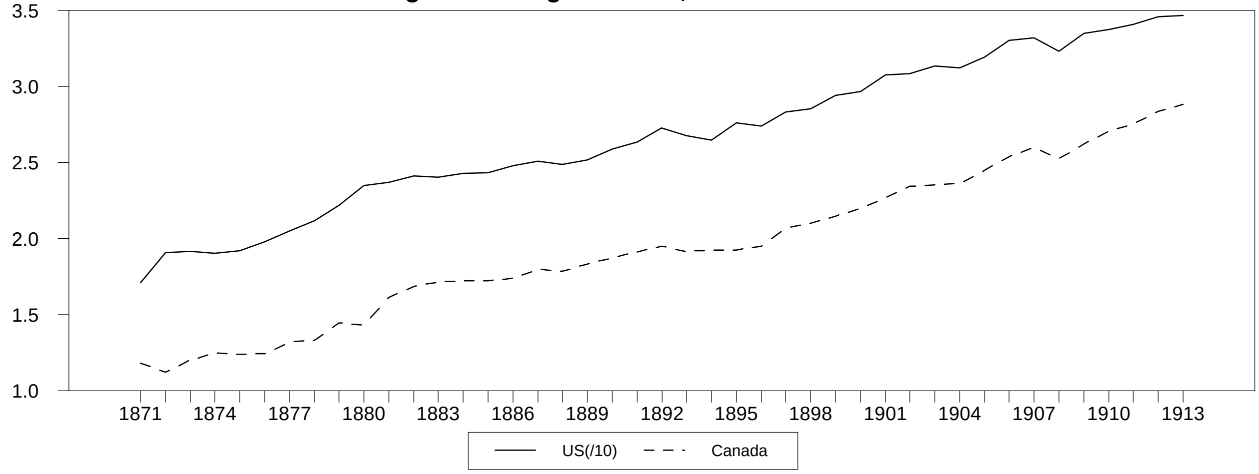


Figure 1b: Per Capita real GDP ($1900), US and Canada

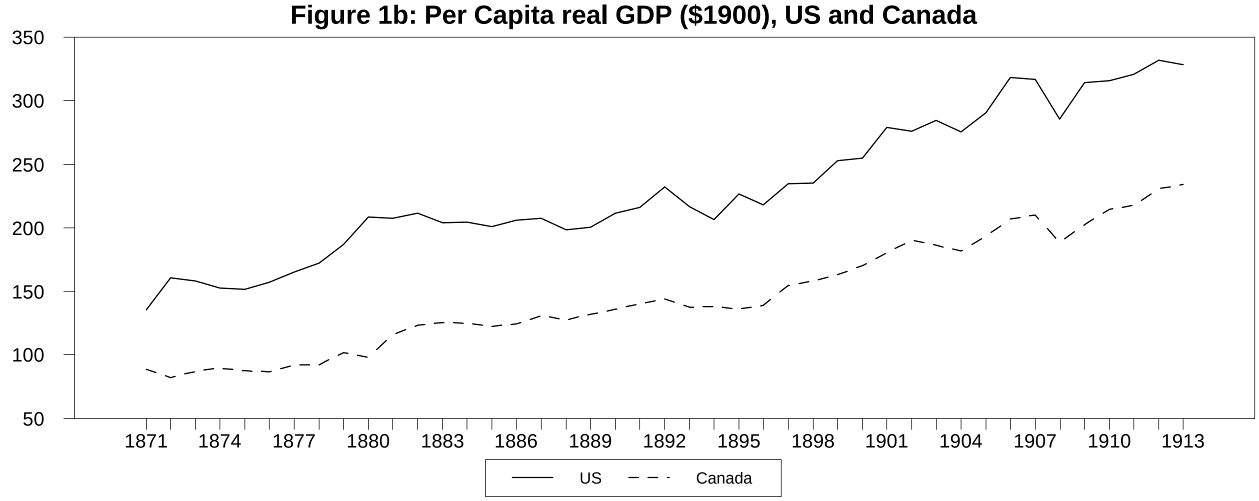


Figure 2a: Price levels (1900=100), US and Canada

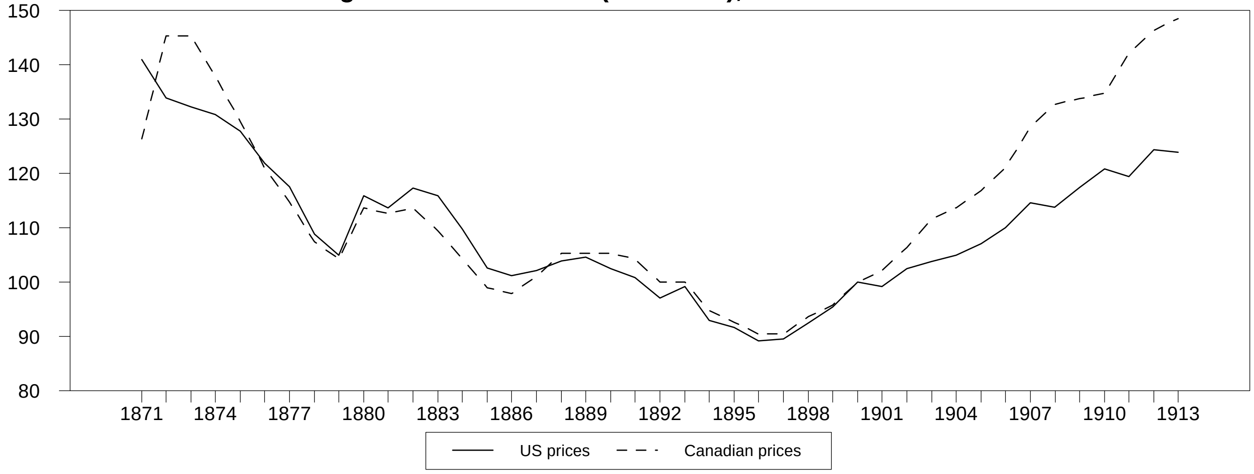


Figure 2b: Canadian terms of trade and price level

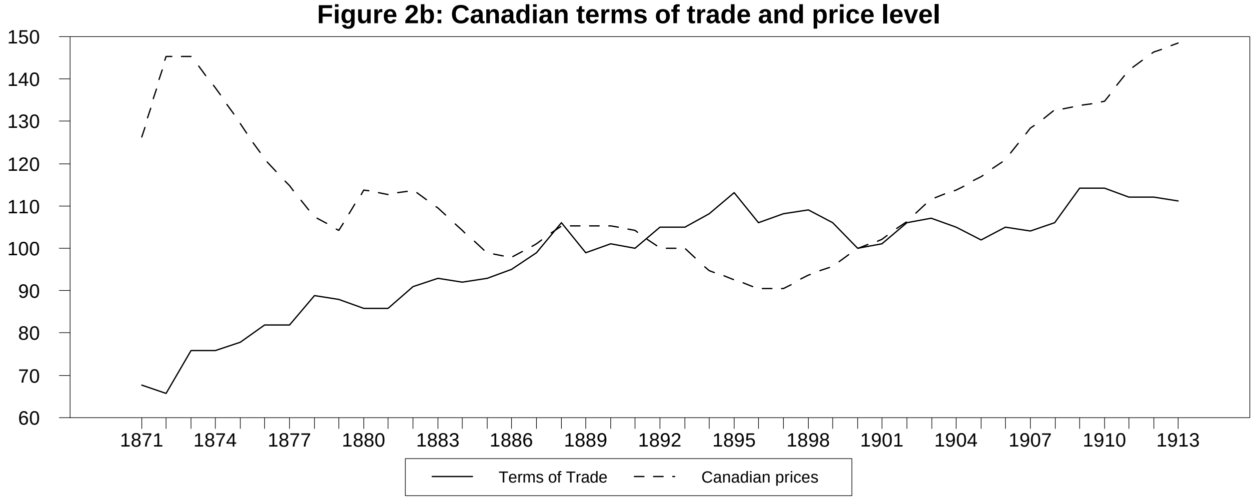


Figure 3a: (log) Per capita money stocks, US and Canada

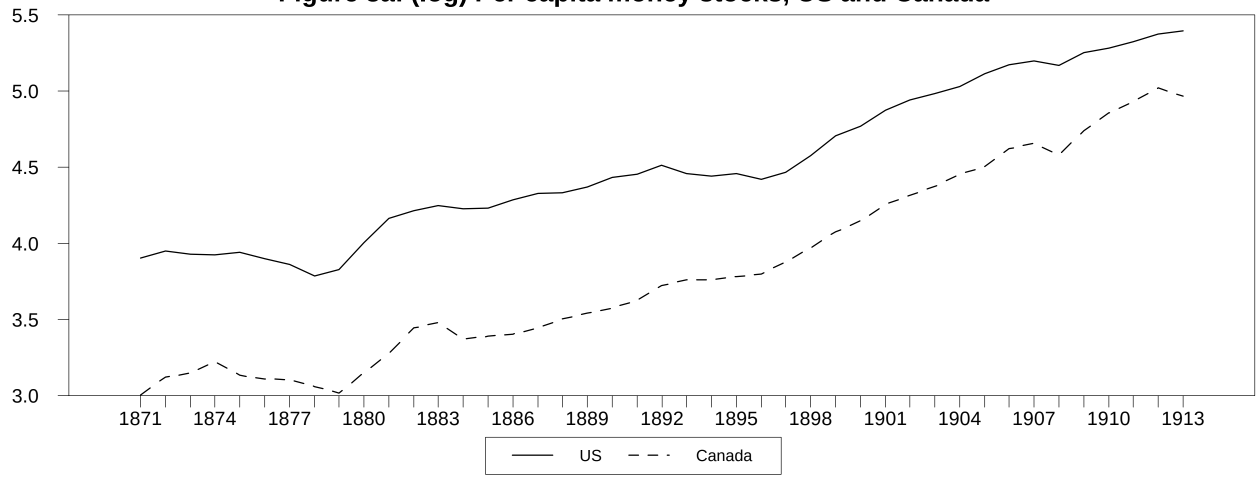


Figure 3b: Annual Gold production

Estimated 1870 Stock: 126mn ozs

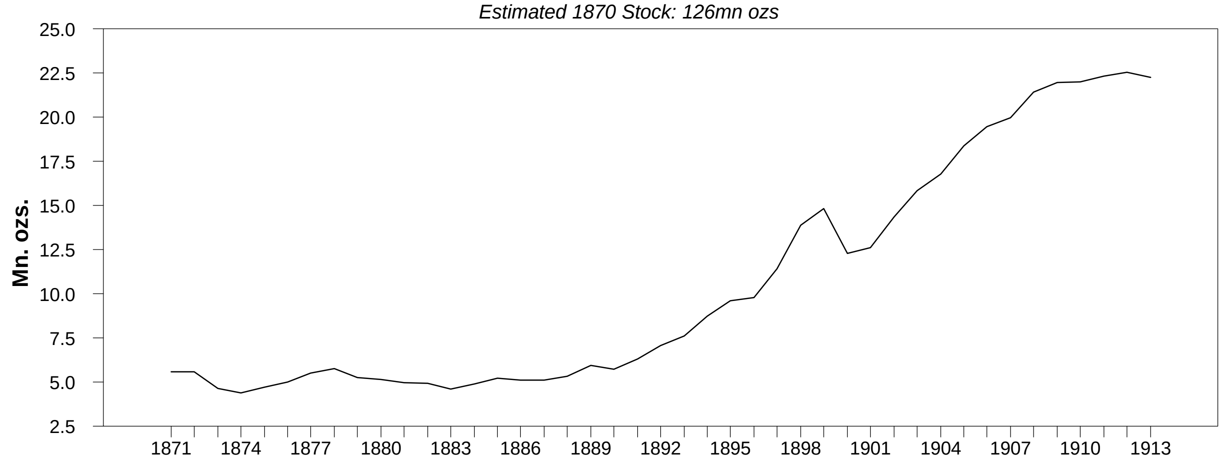


Figure 4: U.S. Impulse Responses

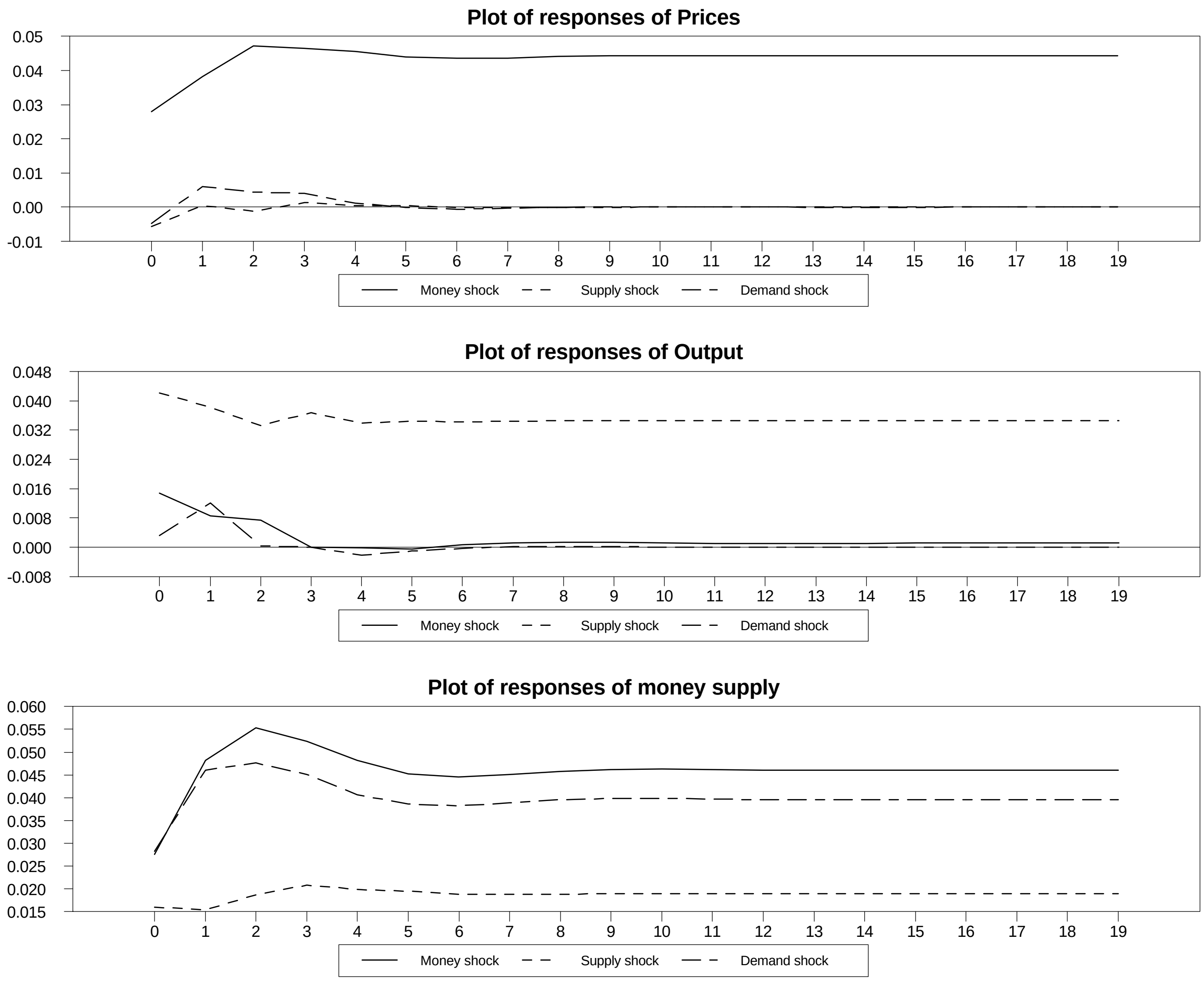


Figure 5: US Shocks

Figure 6: Historical Decomposition of US Prices

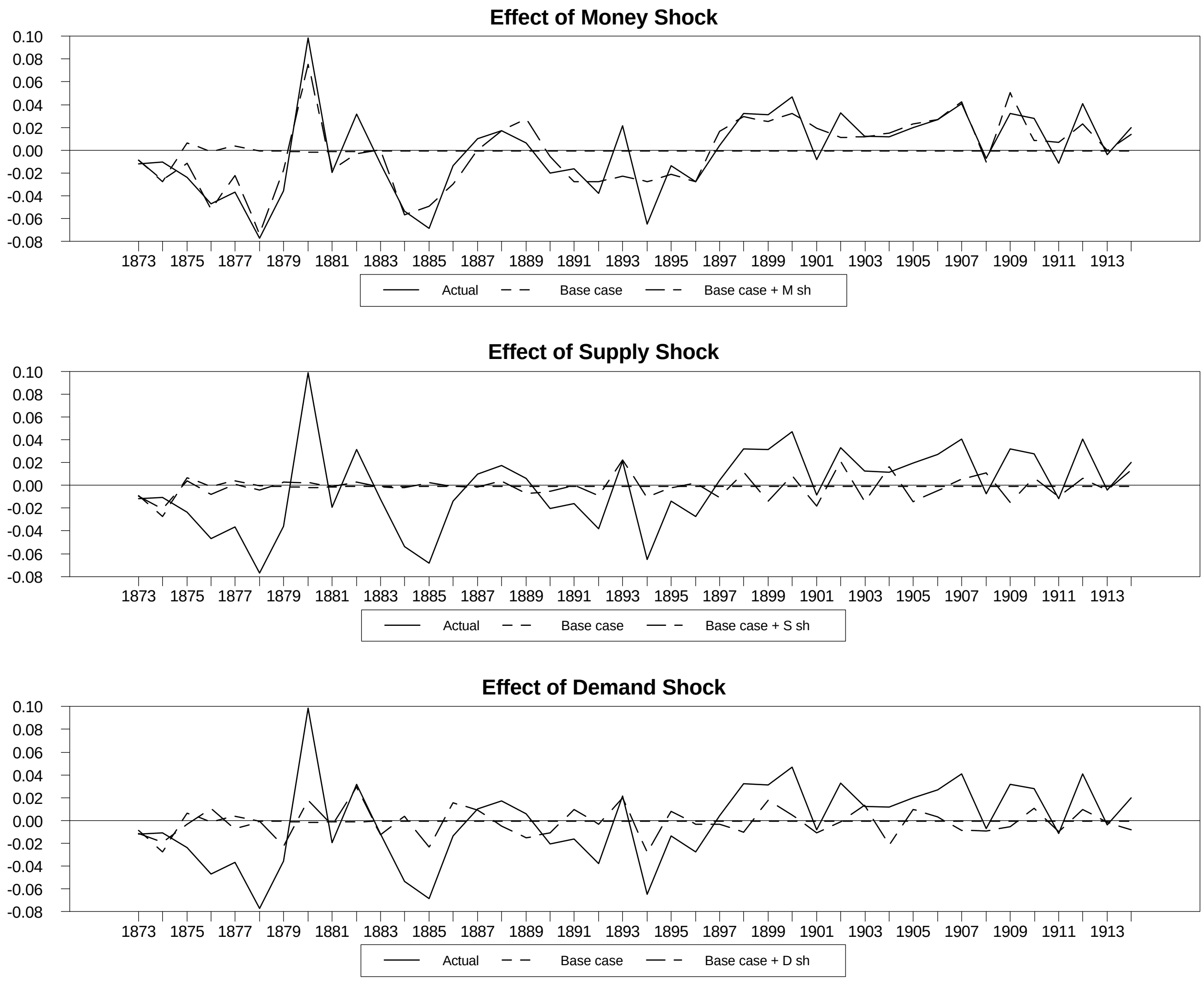


Figure 7: Historical Decomposition of US Output

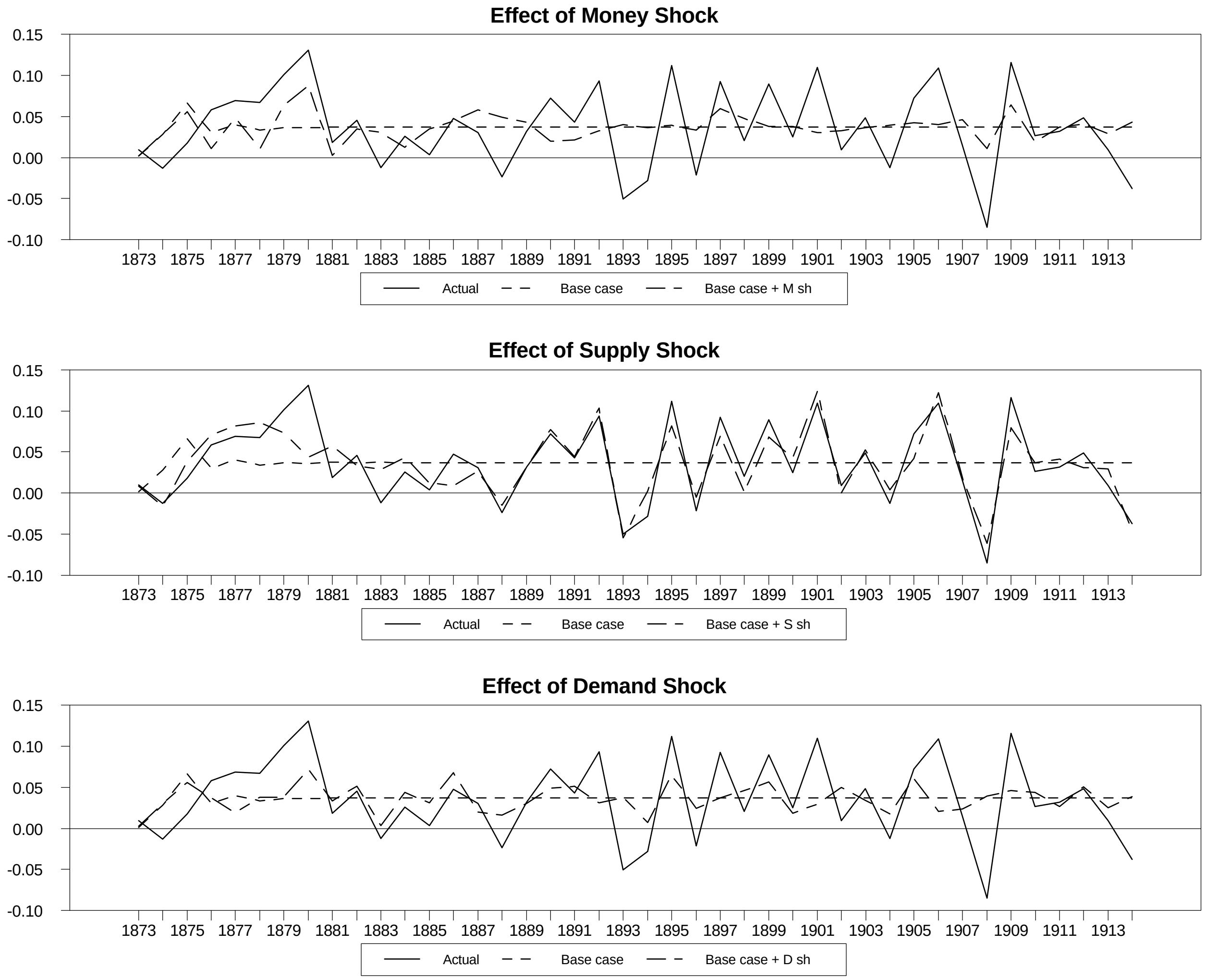
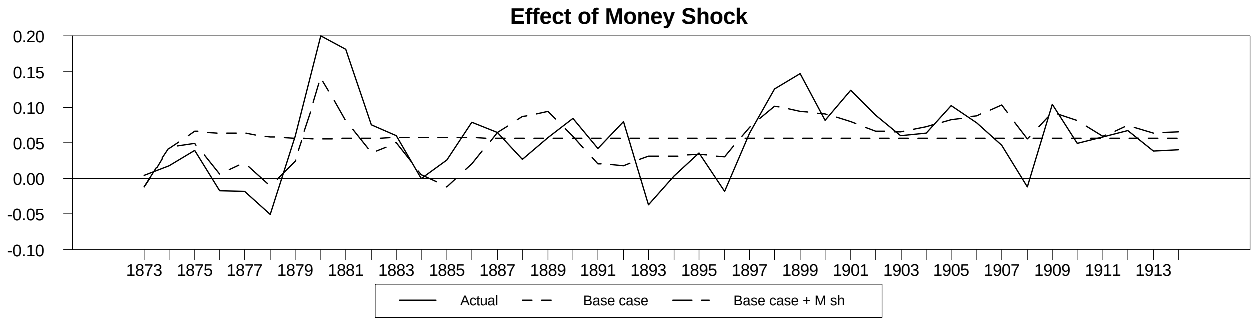
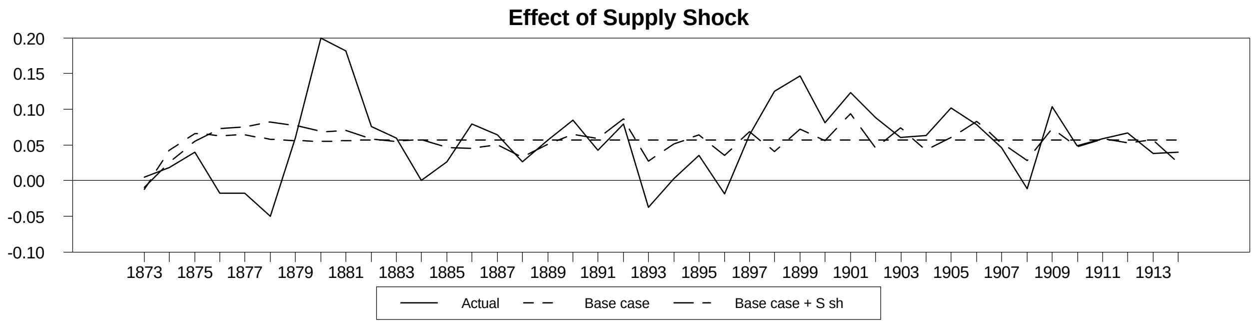


Figure 8: Historical Decomposition of US Money





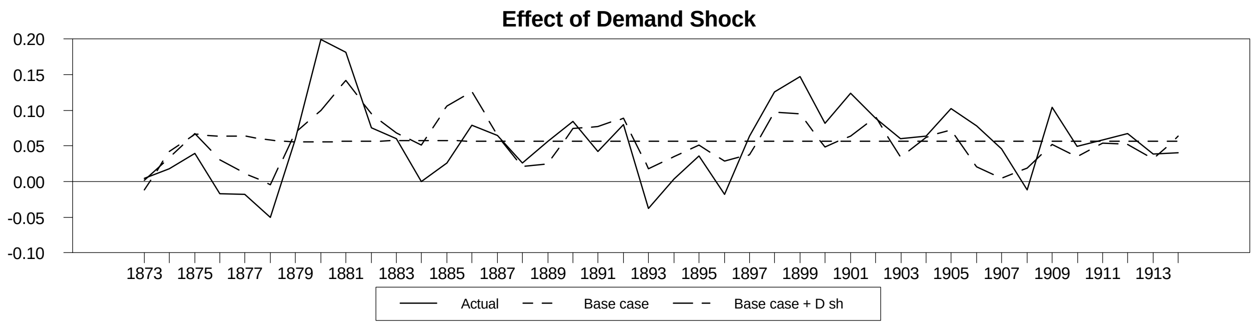


Figure 9: Canadian Impulse Responses

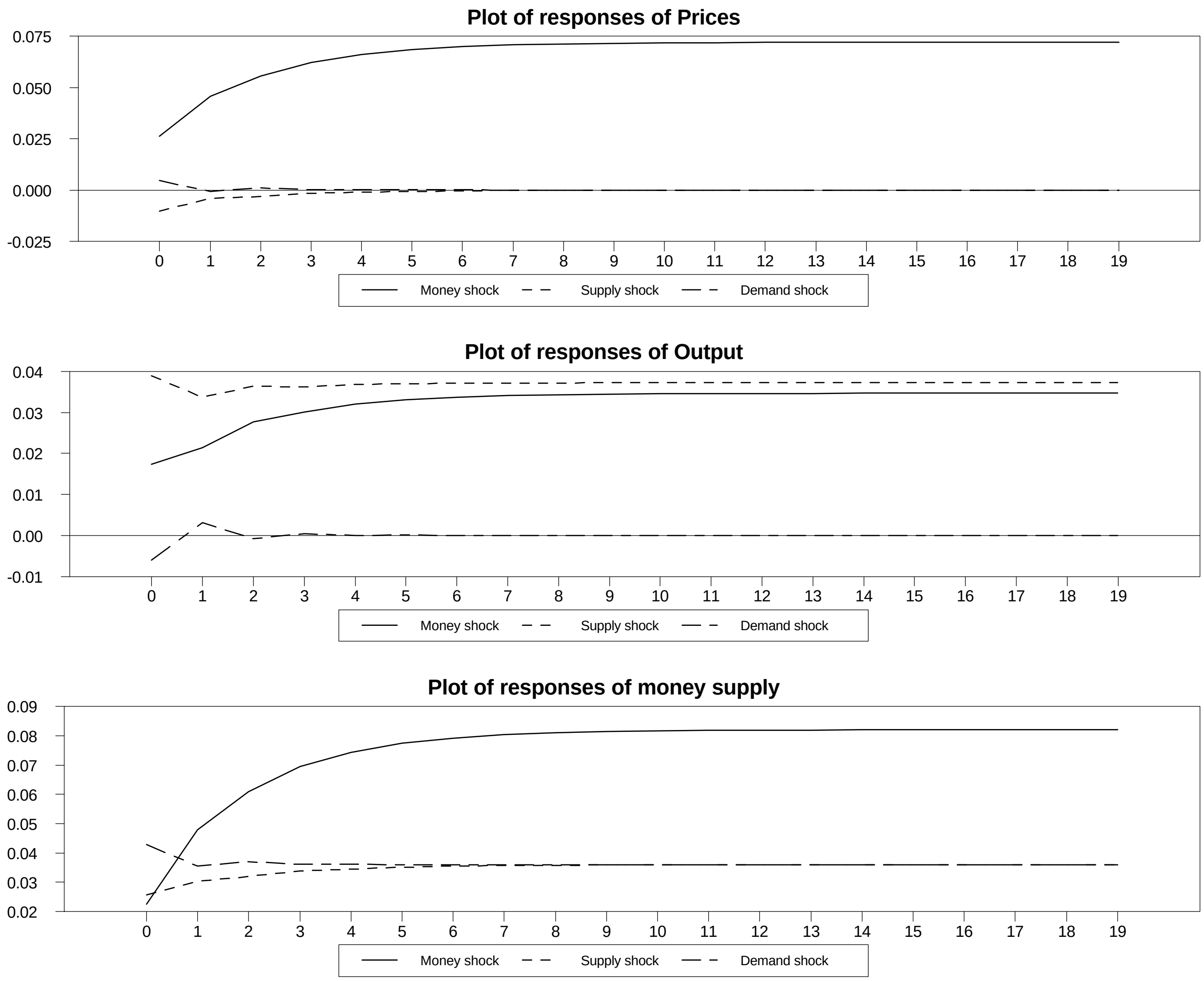


Figure 10: Canada Shocks

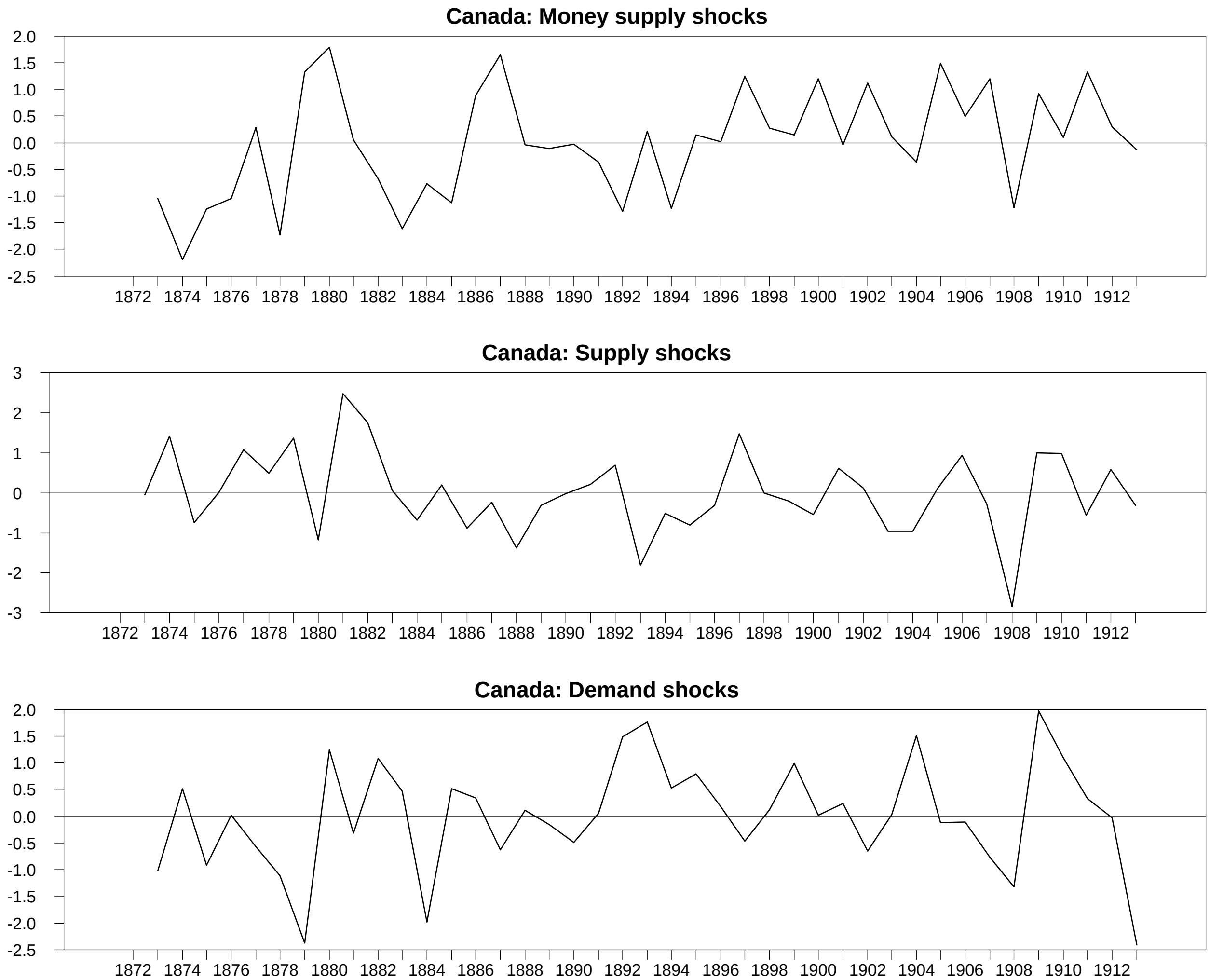


Figure 11: Historical Decomposition of Canadian Prices

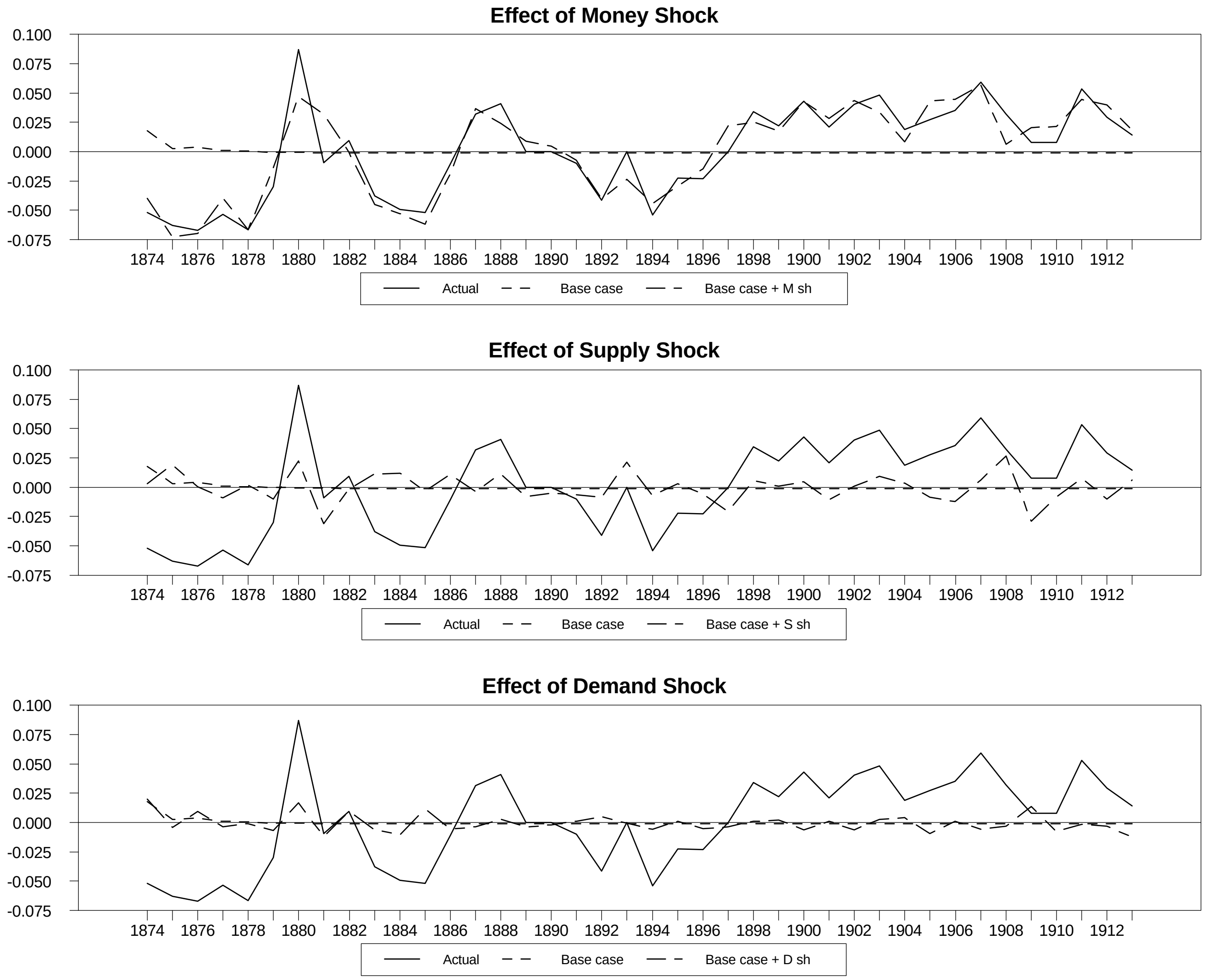


Figure 12: Historical Decomposition of Canadian Output

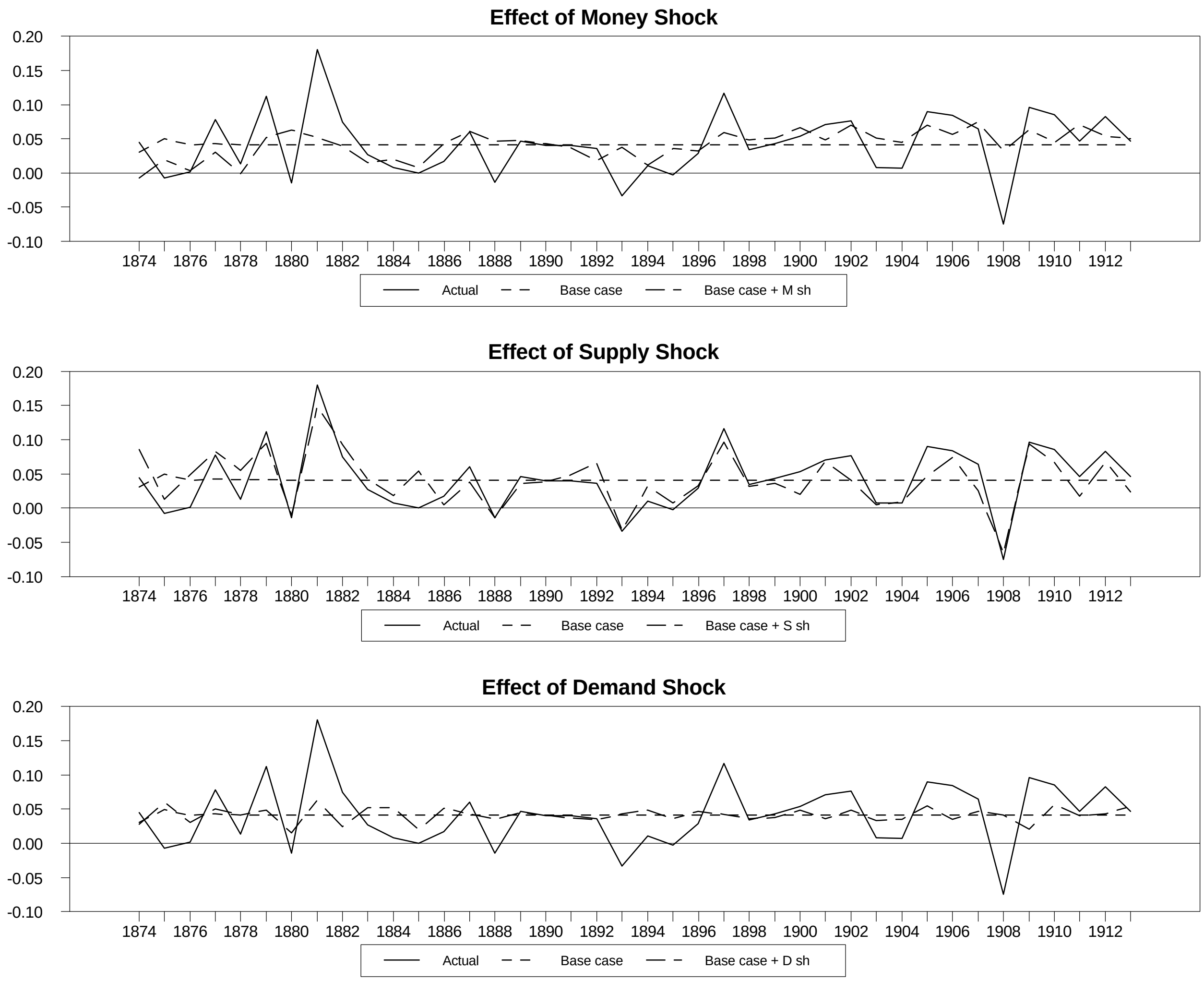


Figure 13: Historical Decomposition of Canadian Money