

UNIVERSITY OF MONTREAL

**WHICH ARE THE EFFECTS OF A MONETARY POLICY SHOCK ON THE
DIFFERENT COMPONENTS OF GDP (CONSUMPTIONS, INVESTMENTS,
EXPORT OF GOODS AND SERVICES, IMPORTS OF GOODS AND
SERVICES) IN CANADA?**

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TABLE OF CONTENTS

SUMMARY	2
1. INTRODUCTION	3
2. LITERATURE REVIEW	5
3. EMPIRICAL METHODOLOGY	13
3.1 Standard VAR analysis of monetary policy	13
3.2 A sectoral model of monetary policy	16
3.3 Identifying monetary policy shocks	18
3.4 Sectoral effects of monetary policy in Canada	20
4. CONCLUSION.....	23
5. REFERENCES	25
6. TABLES	27

SUMMARY

This paper studies the effects of a monetary policy shock on the different components of GDP (consumption, investments, exports of good and services, imports of good and services) in Canada.

This paper examines two important and controversial questions in macroeconomics:

- 1) Does the monetary policy affect the real economy;
- 2) If it does, what is the transmission mechanism by which these effects happen, how long does it take for the variables to come back to the equilibrium?

The results derived from this analysis may be very useful for economists who are looking for building better models of the monetary transmission in Canada. We may expect to find a link between the output composition and the effectiveness of monetary policy, which may be very important for policymakers.

1. INTRODUCTION

This paper presents an empirical methodology based on the estimation of a vector autoregression model (VAR) to analyze the sectoral effects of monetary policy. This methodology allows us to compare the effects of monetary policy across sectors in terms of their delay and persistence.

In the literature there is a debate about the capacity of an interest-rate based monetary policy to deal with sectoral shocks. There are two aspects in this debate. The first one is about the sectoral effects of monetary policy. For instance, monetary policy has a strong redistributive component if different sectors of the economy have different interest rate sensitivities. In such a case, aggregate output stabilization through monetary policy would be achieved by including larger cyclical fluctuations in interest rate sensitive sectors.

A different reason to care about the heterogeneous effect of monetary policy is the implications it has about the effectiveness of monetary policy as a policy tool. The ability of an interest-rate-based monetary policy to start the economy will depend on the relative importance of high interest rate sensitivity sectors as a fraction of GDP.

The methodology we propose here is based on the standard VAR models of monetary policy (Bernanke and Blinder (1992), Bernanke and Mihov (1998), Christiano and Eichenbaum (1992), Christiano, Eichenbaum and Evans (1999)) that decomposes aggregate GDP and includes its components in a VAR, non-simultaneously.

The identification of a structural VAR is based on standard assumptions that monetary policy responds contemporaneously only to the aggregate price index and GDP, and that all the components of GDP responds to monetary policy only with a lag.

We apply this methodology to Canada data. We decompose GDP into several components – consumption of durable goods, semi-durable goods, non-durable goods, services, investments in business gross capital formation, investments in residential structures, investments in non-residential structures and equipment, government gross

fixed capital formation and government investment in inventories – and characterize the response of each of these components to a monetary policy shock.

The results we obtain show that, at this level of aggregation, there are important differences across components in the response to monetary policy.

The rest of the paper is structured as follows: in chapter 1 we make an introduction, chapter 2 continues with the literature review; in chapter 3 we make a full description of the model used and we look at the sectoral effects of a monetary policy shock in Canada. Chapter 4 concludes this paper and in chapter 5 we mention several references. Chapter 6 presents the graphs obtained in our analysis.

2. LITERATURE REVIEW

The study of the macroeconomic effects of monetary policy has been the subject of an important amount of literature.

One of the most important study about the monetary transmission mechanism was done by L. Dedola and F. Lippi in 2003 “The Monetary Transmission Mechanism – Evidence from the Industries of Five OECD Countries“, paper that measured the effects of unanticipated monetary policy on industrial output by means of a structural VAR applied to 21 manufacturing industries in each of the 5 countries considered.

Their starting point was the estimation of 5 country VARs (for France, Germany, Italy, the U.K. and the U.S.A.) using monthly data for the 1975-1997 period. For all countries the operating instrument of monetary policy is the short-term interest rate, as is very common in the literature, and they also considered that disaggregated data (at the industry level) can be more useful in understanding the monetary transmission mechanism than aggregate data because of two reasons.

First, several determinants of monetary policy effectiveness suggested by economic theory vary more across sectors within a country than across the aggregate data of developed countries and second, the cross-industry dimension allows them to make progress on some identification problems beleaguering the study of the monetary transmission, because it offers a richer set of controls.

After documenting the industry effects of monetary policy, it was used an original firm-level database to measure some industry features which, according to monetary transmission theories, are likely to affect the size of the policy effect.

Then, they analyzed the relationship between the industry effects of monetary policy and these industry features.

The analysis reveals that the effects are systematically related to factors that affect both industry demand and supply sensitivity to interest rate changes, namely the industry

output - durability, financing requirements (short-term debt and working capital) and borrowing – capacity (firm-size, leverage and interest rate burden).

To measure the output effects of exogenous monetary policy shocks, they used structural vector auto regression (SVAR), however the impulse responses generated by the SVAR are not an estimate of the total effects of monetary policy. Despite the ongoing debate on their usefulness, their widespread use makes the results comparable to previous studies. The identification method that they used relies on the recursiveness assumption presented in Christiano, Eichenbaum and Evans (1999), mainly because of its simplicity.

The impulse response functions show that with a tight monetary policy there is a temporary reduction of industrial activity and the money stock, facts that are consistent with the theory about the long-run neutrality of money and the short-run effectiveness of policy.

The impact of policy on industrial output is usually negative in all of the countries and in several cases it is statistically different from zero at 95% confidence interval. The VAR specification for the European countries also includes the exchange rate, due to the fact that the European countries are more open to the foreign exchange than the U.S.A.

The researchers noticed that within each country, industry responses differ very much both qualitatively and quantitatively. For example, in the food industry the impact on production is not significantly different from zero.

On the contrary, the heavy industries (iron, machinery) demonstrate a response to policy to a greater degree than other industries.

The conclusions of this paper are:

- a decomposition of the sectoral effects into industry-specific and country-specific components indicates no significant cross-country differences in the transmission mechanism of monetary policy;
- the impact of monetary policy is stronger in industries that produce durable goods, have greater financing requirements (working capital) and a smaller borrowing capacity (smaller size and leverage ratio).

Another important paper that treated this subject was written by Ben Bernanke and A. Blinder in 1992 “ The Federal Funds Rate and the Channels of Monetary Transmission “, which was organized under the idea that the Federal Funds rate or the spread between the funds rate and some alternative open-market rate is an indicator of Federal Reserve policy. If so, the dynamic response of the economy to innovations in the funds rate, or in the funds-rate spread, will measure the true structural response to monetary policy. The idea was to look at the monetary transmission mechanism by examining the responses to a Federal funds rate shock of a bank balance-sheet variables, like deposits and loans, and target variables, like unemployment and inflation. They insisted on the idea that the funds rate, or the funds rate spread, is a measure of monetary policy and did this in three steps:

- 1) if the funds rate is a measure of policy and if policy affects the real economy, then the funds rate should be a good reduced-form predictor of major economic variables;
- 2) if the Federal funds rate measures monetary policy, then it should respond to the Federal Reserve’s perception of the state of the economy;
- 3) finally they make the case that movements in the funds rate are genuine policy changes, not simply endogenous responses of the Federal funds market to changes in the economy.

Three VARs were estimated, each including an indicator of monetary policy based on the funds rate, the unemployment rate, the log of the CPI and the log levels of three bank balance – sheet variables (deposits, securities and loans), all deflated by the CPI. From each estimated VAR, they calculated the impulse-response functions to a shock to the monetary indicators and, assuming that innovations to the indicators represent policy actions, the responses of the other five variables will trace out the dynamic effects of such an action on the banking system and the economy.

Tight monetary policy (an increase in the federal funds rate) does reduce the volume of deposits held by depository institutions. The effect starts immediately, grows gradually, reaches its maximum in about nine months, and appears to be permanent, which means that bank assets fall along with bank liabilities.

For the first six months after the policy shock, the fall in assets is concentrated almost entirely in securities, loans hardly move, however, shortly after, security holdings begin gradually to be rebuilt, while loans start to fall and, after two years, security holdings have almost returned to their original value, and the entire decline in deposits is reflected in loans.

The fact that nominal interest rates are good forecasters of real variables should be refined to note that the Federal funds rate is an informative variable.

The finding that the Federal funds rate dominates both money and the bill and loan rates in forecasting real variables seems more robust than the finding of Sims (1980) and Litterman and Weiss (1985) that the bill rate dominates money.

Finally, the conclusion is that the monetary policy affects the composition of bank assets. Tighter monetary policy results in a short-run sell-off of banks' security holdings, with little effect on loans.

Over time, this policy is felt on loans, as bank terminate old loans and refuse to make new ones.

One of the last papers that I would like to mention would be "The Cost Channel of Monetary Transmission" by M. Barth III and V. Ramey (2000).

Traditional economic models say that changes in monetary policy have an effect upon the economy through a demand channel of transmission. This view of monetary policy has a long history and there has been debate over whether monetary policy affects real economic variables, and if so, how powerful these effects may be.

Much of this research has been devoted to identification of a demand-side transmission mechanism for monetary policy and quantifying its effects.

Some researchers have proposed that there may be important supply-side, or cost-side, effects of monetary policy (Galbraith, Shapiro, and Blinder).

This paper presents industry-level evidence on comovements between prices and output that suggests that these cost-side theories of monetary policy transmission deserve more consideration.

There are a lot of reasons, both theoretical and empirical, to consider the importance of cost-side effects of monetary policy actions. Just as interest rates and credit

conditions affect firms' long-run ability to produce (by investing in fixed capital), they can also be expected to affect firms' short-run ability to produce (by investing in working capital).

Bernanke and Mihov (1998), Christiano, Eichenbaum and Evans (1994), Bernanke and Gertler (1995), and others have used vector autoregressions (VAR) to identify monetary policy changes and to see the reaction of different aggregates to those shocks. The results can be summarized in the following facts about the effects of a contractionary monetary policy action:

- 1) Output falls after a lag of about four months, bottoming out nearly two years later, followed by a gradual recovery;
- 2) Short-term interest rates have high transitory responses. Initially higher, they return to previous levels within nine months;
- 3) The price level is unresponsive for almost two years, and then begins to decline to a permanently lower level.

Traditional models try to explain these facts by assuming that sticky wages or prices allow monetary policy to affect real interest rates, which then impact consumer and investment spending.

However, the theoretical assumption of price stickiness is subject to continued debate. It is difficult to explain why a decline in aggregate demand driven by a money shock does not lead firms to lower their prices. Furthermore, these models are inconsistent with the industry-level response of prices for many manufacturing industries.

Another problem with the demand-only view of monetary transmission is the degree of amplification. Empirical evidence suggests that monetary policy shocks that induce relatively small movements in open market interest rates have large effects on output.

Bernanke and Gertler used this result to support their argument that a credit channel working in tandem with the traditional monetary channel explains the data better.

This paper assumed that through some specific mechanism, monetary policy can have effects on an industry's demand as well as its costs. They used a model of supply and demand to develop testable implications about the responses of the industry variables to the various types of shocks.

This approach has several advantages. First, industry prices tend to move much more than the aggregate price level. A second advantage of this approach is that it allows for industry heterogeneity in the possible impact of monetary policy. We would expect monetary policy to have differential impact on industries according to the importance of credit conditions for their demand and supply.

The main reason for choosing their identification scheme is that it allows for control of the so-called “price puzzle” and flexibility in examining the responses of individual time series to monetary policy shocks.

The price puzzle is the finding that aggregate prices rise following a monetary contraction identified by the unexplained portion of the Federal funds rate. Under the traditional view of a demand driven transmission mechanism, this appear to be a puzzle. The proposed solution to this puzzle is that the Federal Reserve has better information about coming inflation than is captured in a parsimonious VAR and reacts appropriately.

The Christiano, Eichenbaum & Evans approach is designed to account for the “feedback function” of the Federal Reserve in identification of policy shocks. The idea is that the Federal Reserve observes contemporaneous values of important aggregate series such as output, prices, commodity prices and demand for reserves before targeting the Federal funds rate, which is the policy instrument of the Federal Reserve. Thus, the portion of the Federal funds rate which is orthogonal to these “feedback” variables is assumed to be an exogenous shift in policy.

The authors followed the Federal funds rate equation by two equations for variables of interest, one for industry output and one for the industry price-wage ratio. Second, they included dummy variables in each equation to control for the cost effects of oil shocks. They controlled for the cost effects of oil shocks by including dummy variables in each equation that take the value 1 during a “Hoover & Perez data” and 0 otherwise.¹

They estimated VAR for total manufacturing, durable manufacturing and non-durable manufacturing, 18 two-digit industries and 2 three-digit industries within these categories over three sample periods: the entire period from February 1959 to December 1996, and

¹ That is, monthly identified by Hoover & Perez (1994) as having an exogenous oil supply shock based on their reading of Hamilton’s (1995) history of post-war oil shocks.

the two sub-sample periods from February 1959 to September 1979 and from January 1983 to December 1996 and observed the effect of a positive Federal funds rate shock on the price-wage ratio and output for the manufacturing aggregates as well as the individual two and three-digit industries using our entire sample of estimation.

For 13 of the 21 industries examined and for all 3 aggregates the impulse response functions show that in response to a positive shock to the Federal funds rate output falls and prices rise relative to wages.

This paper has presented an empirical test that provides evidence to support the fact that monetary policy has supply-side effects on real variables.

The evidence given here shows that in key manufacturing industries, prices rise and output falls following an unanticipated monetary contraction, even after controlling for both the price puzzle and the cost effects of oil shocks. They found that the evidence for the cost channel effects is much stronger during the period from 1959 to 1979 than from 1983 to 1996. During the early period, many more industries showed rising prices in response to a monetary contraction.

Moreover, the effects of monetary policy on output were greater and the price puzzle was more pronounced during the early period. These results are intuitively explained by treating monetary policy as a cost shock to important industries in the U.S. economy.

There are some other studies which find that, for a small open economy such as Canada, the exchange rate is an important channel in the monetary transmission mechanism, as also reflected in the Bank's adoption of the Monetary Conditions Index as a guide to policy. A rise in the interest rate caused by contractionary monetary policy makes domestic dollar deposits more attractive relative to deposits denominated in foreign currencies, leading to a rise in the Canadian dollar, making Canadian goods more expensive than foreign goods, thereby causing a fall in net exports.

Beare (1976) investigates also the impact of monetary policy on Prairie Provinces in Canada during 1956-1971 and finds a differential impact to money supply changes. A major problem is that he does not employ VAR techniques in measuring the effects, thus ignoring the importance of feedback effects among the variables.

Carlino and DeFina (1998) investigate regional effects in the U.S. by employing VAR analysis and find three regions that respond differently from the U.S. average, those being the Great Lakes, the Southwest and the Rocky Mountains.

3. EMPIRICAL METHODOLOGY

3.1 Standard VAR analysis of monetary policy

We will use a Vector Autoregression (VAR) model to estimate the sectoral effects of monetary policy in Canada. The use of VAR to identify exogenous shocks to monetary policy and their effect on different economic aggregates was started by Sims (1980) and then developed by Bernanke and Blinder (1992) and Christiano and Eichenbaum (1992), among others.

VARs have proved to be a convenient method of summarizing the dynamic relationships among variables. Given certain conditions, VARs can also be used to determine the response of economic variables to a fundamental economic shock, a procedure called Impulse Response Analysis. This is of particular interest as we are interested in the response of various variables to monetary policy shocks.

We begin by formally introducing a VAR and discuss the issues involved in measuring the response of variables to fundamental shocks.

The standard model in the literature can be represented by the following VAR:

$$A_0 X_t = \sum_{i=1}^q A_i X_{t-i} + \varepsilon_t, \quad (1)$$

where $X_t = (Z_t, S_t)'$, S_t is the instrument of the Central Bank of Canada, Z_t are the variables in the Central Bank's information set, and q is a non-negative integer.

This specification assumes that the Monetary Authority follows a policy rule that is linear on the variables in Z_t and their lags.

On top of that, it is assumed that the perturbations ε_t have the following properties:

$$E[\varepsilon_t] = 0; E[\varepsilon_t \varepsilon_\tau'] = \begin{cases} D & \tau = t \\ 0 & \text{otherwise} \end{cases}$$

The estimation of this model is normally performed in two steps. First, the parameters of the corresponding reduced form VAR are estimated:

$$X_t = \sum_{i=1}^q B_i X_{t-i} + u_t,$$

then the structural parameters (A_i and D) are recovered by making a series of identification assumptions. The most common used identification assumption in the literature is the “recursiveness assumption”. The idea corresponds to assume that the structural errors (ε_t) are orthogonal ($D=I$) and the matrix summarizing the contemporaneous relations between the variables in the VAR (A_0) is block diagonal. That is, it is assumed that the variables in X_t can be arranged as $X_t = (Z_{1t}', S_t, Z_{2t}')$ and

$$A_0 = \begin{matrix} & a_{11} & 0 & 0 \\ & a_{21} & a_{22} & 0 \\ & a_{31} & a_{32} & a_{33} \end{matrix}$$

The recursiveness assumption corresponds to say that the monetary policy rule responds to contemporaneous values of the variables in Z_{1t} , but these variables respond to the monetary policy instrument only with a lag. Analogously, variables in Z_{2t} are contemporaneously affected by the monetary policy instrument, however they affect the monetary policy rule with only one lag.

It can be demonstrated that the assumption is sufficient to identify the column of A_0 associated with the monetary policy instrument, which is enough to determine the response of all the variables to a monetary policy shock, however identification through the recursiveness assumption does not permit to determine the response of the different variables to any other structural shock.

The set of variables included in the monetary policy rule (Z_t) varies considerably among the papers in the literature. The simplest model considers a measure of activity (usually GDP) and a measure of price level (usually the CPI or the GDP deflator).²

² Most of the papers also include a measure of commodity price to account for the “price puzzle” (see Christiano, Eichenbaum, and Evans (1999))”

There are also differences regarding the variable to include as the monetary policy instrument. While some papers argue in favor of using the Federal Funds Rate (Bernanke and Blinder (1992), Bernanke and Mihov (1998)), others have argued in favor of using the level of non-borrowed reserves (Christiano and Eichenbaum (1992)) or the ratio of non-borrowed to total reserves (Strongin (1995)). Regardless of the monetary policy instrument considered, the literature typically assumes that the monetary policy rules responds to contemporaneous values of the measures of activity and prices, but these respond to the monetary policy instrument only with a lag.³

This methodology has proved to be very useful in understanding the dynamics of a monetary economy, however it can be criticized. The zero-restrictions implicit in the block diagonal structure of A_0 is arbitrary and has been subject to debate.

In summary, the standard way of determining the effects of monetary policy in the literature is to estimate a reduced form VAR model including at least a measure of activity, price level, and a monetary policy instrument. The recursiveness assumption is then used to identify the relevant structural parameters. In the next section we will show how, with some modifications, this simple framework can be extended to the analysis of the sectoral effects of monetary policy.

³ Bernanke and Blinder (1992) and Christiano, Eichenbaum, and Evans (1996b) consider also the possibility that the monetary policy instrument responds only with a lag to activity and prices, which respond contemporaneously to the monetary policy shock.

3.2 A sectoral model of monetary policy

As discussed in the previous section, the simplest model of monetary policy in the literature considers a monetary policy rule based on aggregate activity and prices.

The structural VAR representation of this model corresponds to equation (1), where $X_t = (Y_t, F_t)$, Y_t is the GDP level and F_t is the Federal Funds rate, is the policy instrument.

The model is usually estimated in reduced form, and the structural parameters relevant for the transmission of monetary policy are recovered using the recursiveness assumption.

To understand the sectoral effects of monetary policy, we decompose the measure of activity into N different components, so $X_t = (Y_{1t} \dots Y_{Nt}, F_t)$. If we were to identify this VAR through the recursiveness assumption we would have to assume that:

$$A_0 = \begin{matrix} & A_{11} & A_{12} & 0 \\ & A_{21} & a_{22} & 0 \\ & A_{31} & a_{32} & a_{33}, \end{matrix}$$

where A_{ij} are the natural expansions of the a_{ij} elements to N variables.⁴

However, the disaggregating of the measure of activity into its components would lead us very quickly into a degrees of freedom problem.

Another problem with the use of the recursiveness assumption to estimate the sectoral model is that it can only identify the sectoral effects of monetary policy, but it cannot identify the effects of a sectoral shock on the rest of the economy.

Identifying the effect of those shocks requires assumptions on the coefficients of A_0 beyond the block diagonal structure.

⁴ For example, a_{31} is a 1x1 element that corresponds to the response of the interest rate to output, and then A_{31} is the 1xN vector of how the N sectors impact the interest rate.

It requires that enough conditions are imposed on the coefficients of A_{11} so that each equation can be individually identified.

The approach typically followed in the literature on the sectoral effects of monetary policy (Barth and Ramey (2001), Dedola and Lippi (2000)) is to estimate a structural VAR that includes aggregate variables (GDP, a price index, and a commodity price index), the monetary policy instrument (usually the federal funds rate), and an index of industrial activity (typically an industrial production index) – in that order – and that identifies the effects of monetary policy using the recursiveness assumption.

That is, they assume $X_t = (Y_t, P_t, CP_t, F_t, Y_{it})'$. Under the standard recursiveness assumption the ordering of this VAR assumes that the monetary policy rules reacts contemporaneously to the values of Y_t , P_t and CP_t , but those variables react to the monetary policy instrument with only a lag. It also assumes that monetary policy responds to the activity of sector i with only a lag, but sector i is affected contemporaneously by the monetary policy instrument. It is clear that these two sets of hypothesis are mutually inconsistent: we cannot assume simultaneously that monetary policy does not affect any component of aggregate activity contemporaneously, but it does affect contemporaneously the sum of them.

By estimating a different VAR for each sector these papers permit variation both on the parameter of the monetary policy rule and on the information set relevant for the monetary policy response. This affects the ability of the model to make meaningful comparisons about the effects of monetary policy across sectors.

3.3 Identifying monetary policy shocks

In this paper we are interested in seeing how an increase or a decrease in the interest rate affect some variables in GDP, if that shock affect all of them or only some of them, and how long it takes for those affected variables to come back to the equilibrium point.

The path whereby the variables return to the equilibrium point is called the impulse response of the VAR, which traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables.

We want to estimate 9 VARs to see the effects of an interest rate shock to each component of GDP in Canada.

We have the equation $A_0 X_t = \sum_{i=1}^q A_i X_{t-i} + \varepsilon_t$, where $X_t = (I_t, Y_t)'$. I_t is the policy instrument at time t , Y_t is the information set of the policy maker, and ε_t is the policy innovation orthogonal to the information set, i.e. the monetary policy shock.

In identifying monetary policy shocks, three issues need to be addressed. First, one has to determine which variable accurately measures the instrument of monetary policy.

Secondly, one has to determine the set of variables to which the central bank observes and responds, i.e. the set of variables that comprise the information set.

Thirdly, one has to take a stand on the interaction of the monetary policy shock with the variables in the information set.

Concerning the third issue, one stand is to assume that a shock to the policy instrument is orthogonal to the information variables. An unrestricted VAR incorporates this identification strategy. In assuming that the innovations are orthogonal to the information variables, in ordering the variables in the VAR, the information variables must be prior to the instrument variable. Any variables ordered after the instrument implies that the monetary authority does not react, within the period, to a change in this value. This chosen ordering implies that, while setting the instrument rate at time t , the

monetary authorities observe the contemporaneous values of the variables that are prior to the instrument in the VAR ordering, and any lagged values of the variables are ordered after the instrument.

As a matter of fact, the monetary authority only looks at predetermined variables when setting its policy instrument. This identification structure allows us to use the fitted residuals in the OLS regression of the instrument on the information variables as estimates of policy shocks.

A second stand is that the monetary authorities do not look only at predetermined variables when setting their instrument. They also look at contemporaneous variables that in turn are contemporaneously affected by changes in the instrument. So in light of a change in one of the information variables, the authorities adjust the instrument. It may then be the case that the change in the instrument will feed back into the behavior of the information variable.

A typical case is with a small open economy, like Canada, where, due to the significance of the exchange rate channel, authorities have the exchange rate in their information set. If the instrument is the short-term interest rate, a change in this variable contemporaneously affects the exchange rate. Using OLS to estimate the reaction function would yield biased estimates of the coefficient in the reaction function and thus biased estimates of the structural disturbances, thus making impulse response analysis in the context of monetary policy shock meaningless. The issue is that the feedback effect cannot be captured in the recursive approach; ordering the exchange rate before the instrument (as it is part of the information set) prohibits a contemporaneous response from change in the instrument. In this case monetary policy has not been successfully identified, resulting in empirical puzzles from impulse response exercises, where positive domestic interest rate innovations lead to a significant depreciation of the domestic currency.⁵ Studies finding this result are Grilli and Roubini (1995) for the non-U.S. G-7 countries and Cushman and Zha (1997) for Canada.

The identification procedure that captures the feedback effect is the structural VAR approach developed by Bernanke (1986), Blanchard and Watson (1986), and Sims

⁵ For example, if the equation is over identified, Indirect Least Squares estimation is not appropriate. Suitable procedures are Two-stage or Three-stage Least Squares estimation, or Limited or Full Information Maximum Likelihood estimation.

(1986). This approach contains a broader set of economic relations. In general, the same identification principles apply here in ordinary simultaneous equations, where it first needs to be established that the reaction function is identified and then the appropriate estimation procedure is employed. Studies that have utilized a structural approach in identifying monetary shocks include Sims (1986) for the U.S., Gordon and Leeper (1994) for the U.S., Sims and Zha for the U.S., and Cushman and Zha (1998) for Canada.

3.4 Sectoral effect of monetary policy in Canada

This section presents the results obtained to the estimation of the sectoral effects of monetary policy in Canada.

We decompose Canada GDP into 9 components: consumption of durables, consumption of non-durables, consumption of semi-durables, services, investments in business gross capital formation, investments in residential structures, investments in non-residential structures and equipment, exports of goods and services, imports of goods and services and a residual comprising government expenditure and inventory investment.

We take the data for the Canadian economy for the period from 1961 to 2005 for consumption, investments, exports and imports of goods and services.

As an example, we show here a VAR estimate for consumption that can be written as a system of two equations:

$$\begin{aligned}\Delta I_t &= \mu_I + a_{11}\Delta I_{t-1} + a_{12}\Delta C_{t-1} + \varepsilon_{I_t} \\ \Delta C_t &= \mu_C + a_{21}\Delta I_{t-1} + a_{22}\Delta C_{t-1} + \varepsilon_{C_t},\end{aligned}$$

where $\Delta I_t = \log I_t - \log I_{t-1}$;

$$\Delta C_t = \log C_t - \log C_{t-1}.$$

Data is taken at the quarterly frequency. We take the log of those variables to make the computation easier and we seasonally adjust the series of data in order to eliminate the

seasonality effect (for example, during the month of December the consumption increases more than in the other months, and in January and February the consumption usually decreases). The shock of the monetary policy would be an increase or a decrease in the interest rate, interest rate which is established by the Bank of Canada.

The data for the interest rate is also taken from 1961 to 2005, however there are quarterly averages of monthly data.

After that, we estimate an unrestricted VAR, by the least squares method.

In the end, we calculate the impulse response function, where the impulse is “delta log interest“ and the response is “delta log consumption seasonally adjusted”.

The monetary policy shock is equivalent to the regression residuals of the interest rate on the contemporaneous values of consumption. The estimation of VAR for consumption shows that the interest rate equation displays no serial correlation however, as it is common in the VAR literature, the normality of the interest rate equation residuals is rejected.

The figures at the end of this paper show the impulse response functions of the different GDP components to a one standard deviation contractionary shock to the interest rate in Canada.

The monetary policy shock has a significant and lasting effect in 3 sectors: consumption of durables, consumption of semi-durables and residential investment. A minor effect is observed for consumption of non-durables.

As previously found in the literature (Bernanke and Gertler (1995)), investment in non-residential structures and equipment is largely unaffected.

The delay of monetary policy is roughly similar across sectors, however some interesting differences are observed. We notice that the maximum effect of monetary policy is achieved usually 3 quarters of a year after a shock.

This magnitude is similar across those sectors in which monetary policy has a statistically significant effect: the maximum effect of the shock in consumption of durables, consumption of semi-durables, services, investment in business gross capital formation, residential investment and imports of goods and services is also experienced at the third quarter.

The deviations are observed for consumption of non-durables, investment in non-residential structures and equipment and exports of goods and services, with a trough after 5 quarters.

Some differences in delay across these sectors are also observed when we compare the first period in which their response to the monetary policy shock is statistically different from zero.

According to this measure, the delay of monetary policy is shorter in the consumption of durables, consumption of semi-durables, services and imports of goods and services than the consumption of non-durables, investment in business gross capital formation, residential investment and exports of goods and services: while consumption of durables, consumption of semi-durables, services and imports respond almost immediately to the monetary policy shock, the shock has no effect on the consumption of non-durables, investment in business gross capital formation, residential investment and exports until around the second quarter.

One of the sectors with the longest delay to monetary policy is non-residential investment with the lowest level at the seventh quarter. The analysis provides some evidence that investment in non-residential structures and equipment has a particularly slow response to monetary policy because it is around the sixth quarter that the effect of monetary policy is statistically different from zero for reasonable confidence levels.

The impulse response functions also show that the monetary policy shock is highly persistent. This high persistence is observed across sectors, where, consumption for non-durables, consumption for semi-durables, services, investment in business gross capital formation and exports of goods and services have returned to its baseline level after 20 quarters.

A conservative measure of the persistence of monetary policy is given by the number of periods during which the effect of monetary policy is significantly different from zero at conventional levels. Using this measure we obtain that the persistence is of about 9 quarters for consumption of durables, for services and investment in business gross capital formation, 8 quarters for consumption of non-durables, 10 quarters for consumption of semi-durables and exports and imports of goods and services, 14 quarters for residential investment and non-residential structures and equipment.

4. CONCLUSION

In this paper we present a methodology that allows us to investigate the sectoral effects of monetary policy.

We apply this methodology to the Canadian economy and demonstrate that there are interesting differences in the response to monetary policy among Canada sectors.

We use a VAR model, model that was commonly used to do analysis of economic time series and appears to bring some real benefits for forecasting.

This paper draws the conclusion that the interest rate is a good indicator of monetary policy. The interest rate is probably less contaminated by endogenous responses to contemporaneous economic conditions than is the money growth rate.

The impulse response functions plot the response of the VAR to a structural shock to one of the variables. Under the standard recursiveness approach, the standard shocks are orthogonal by assumption, so the source of the innovation is clearly determined. In our case, the structural innovations to different sectors are correlated, so a sectoral shock coincides with simultaneous shocks to the rest of the economy.

In this paper we have used demand components to make claims about sectors. This is a short cut, but one that provides interesting insights about the dynamic response of the different components to monetary policy, however, future research should replicate this result using sectoral output or employment.

Several other questions are left unanswered in this paper. Probably the most important is why different sectors have different sensitivities to monetary policy. We can say that differences in the importance of financial constraints, price stickiness, or durability are potential causes to be explored, and they should also form part of future research.

Finally, this methodology could be an important tool to explore some unanswered questions about the effects of monetary policy and to test different hypothesis about the behavior of the monetary authority. For example, within academic and policy circles is frequently said that the monetary authority pays more attention to some specific sectors, like residential investment, to decide the stance of monetary policy.

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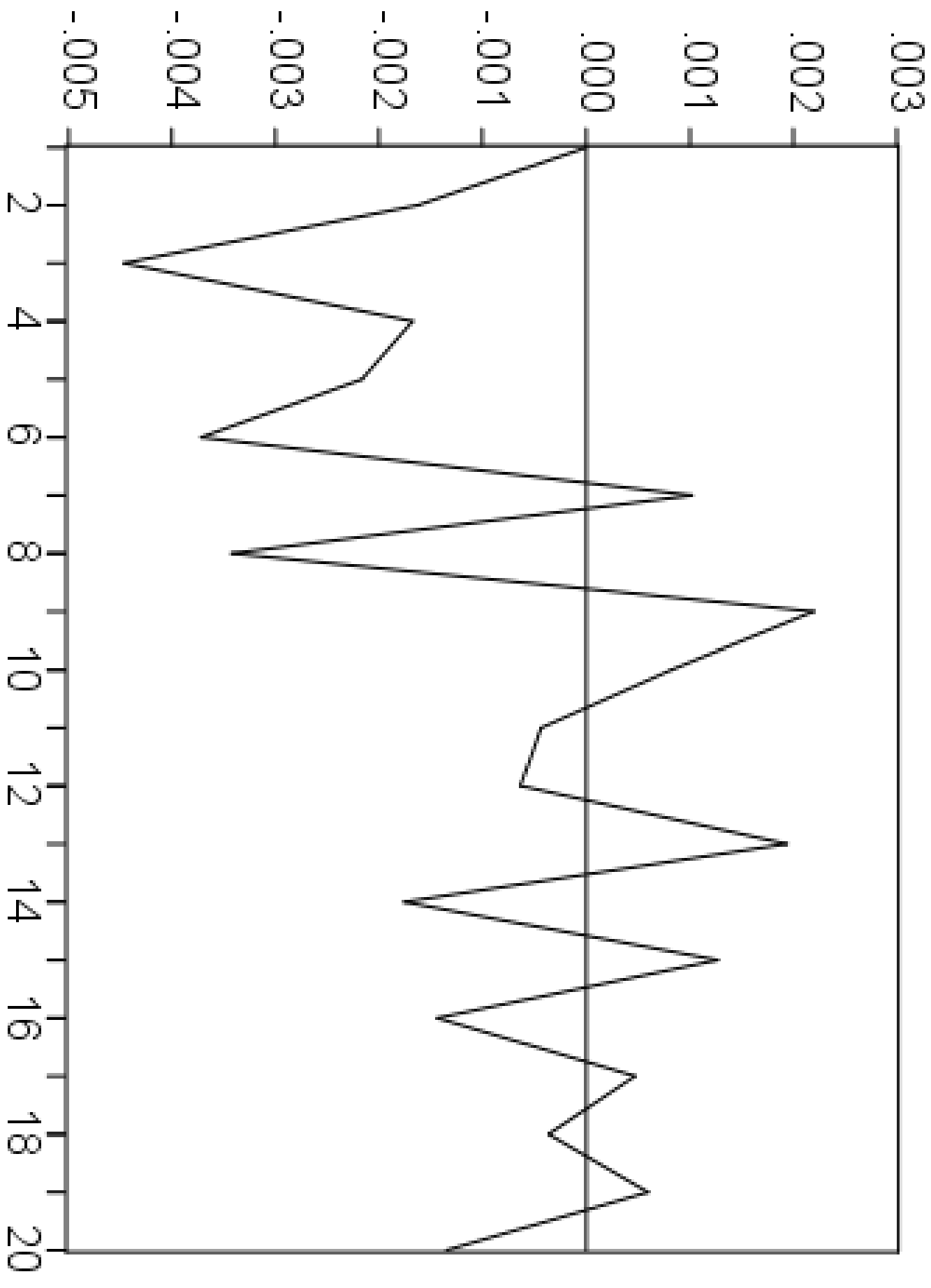
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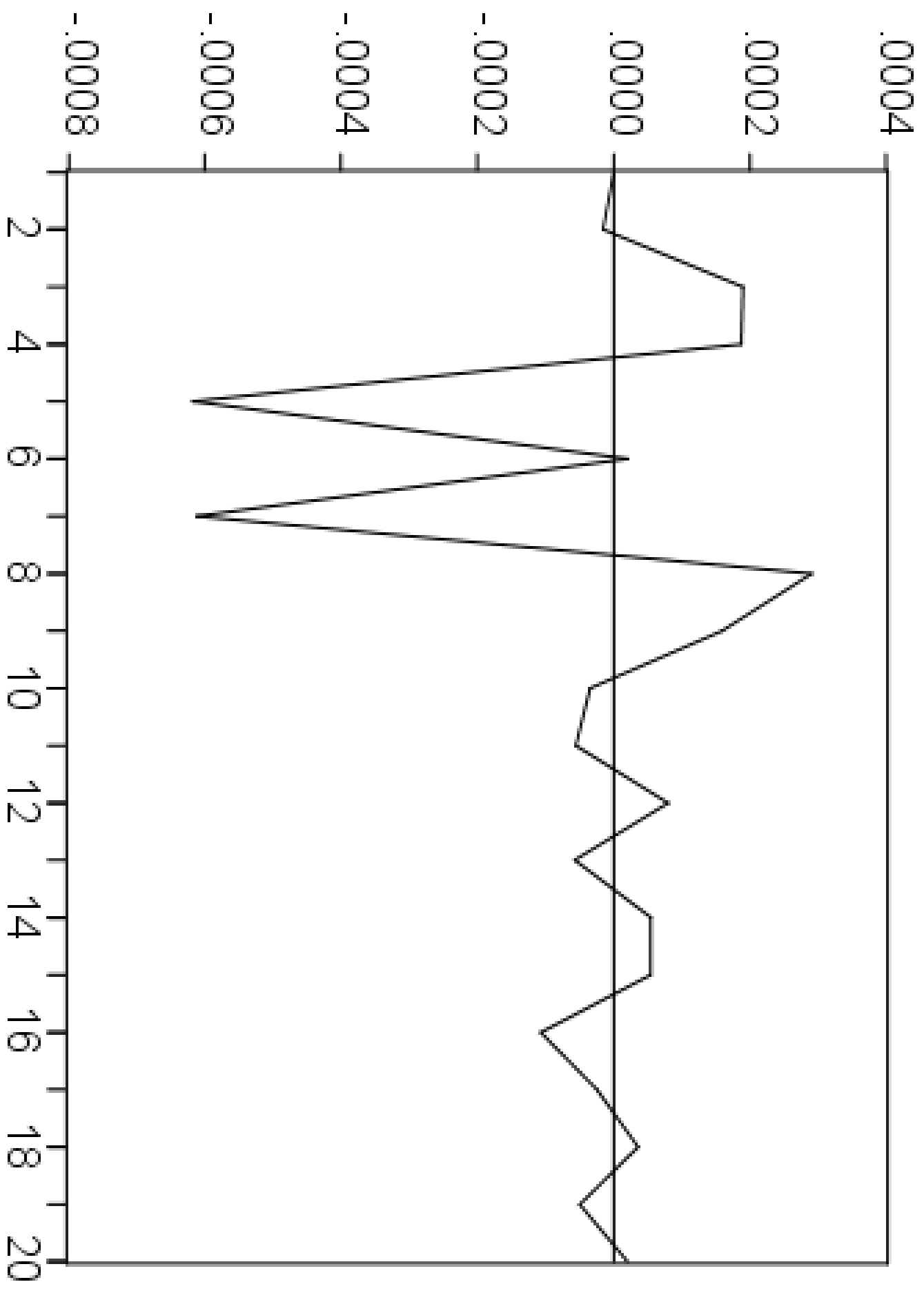
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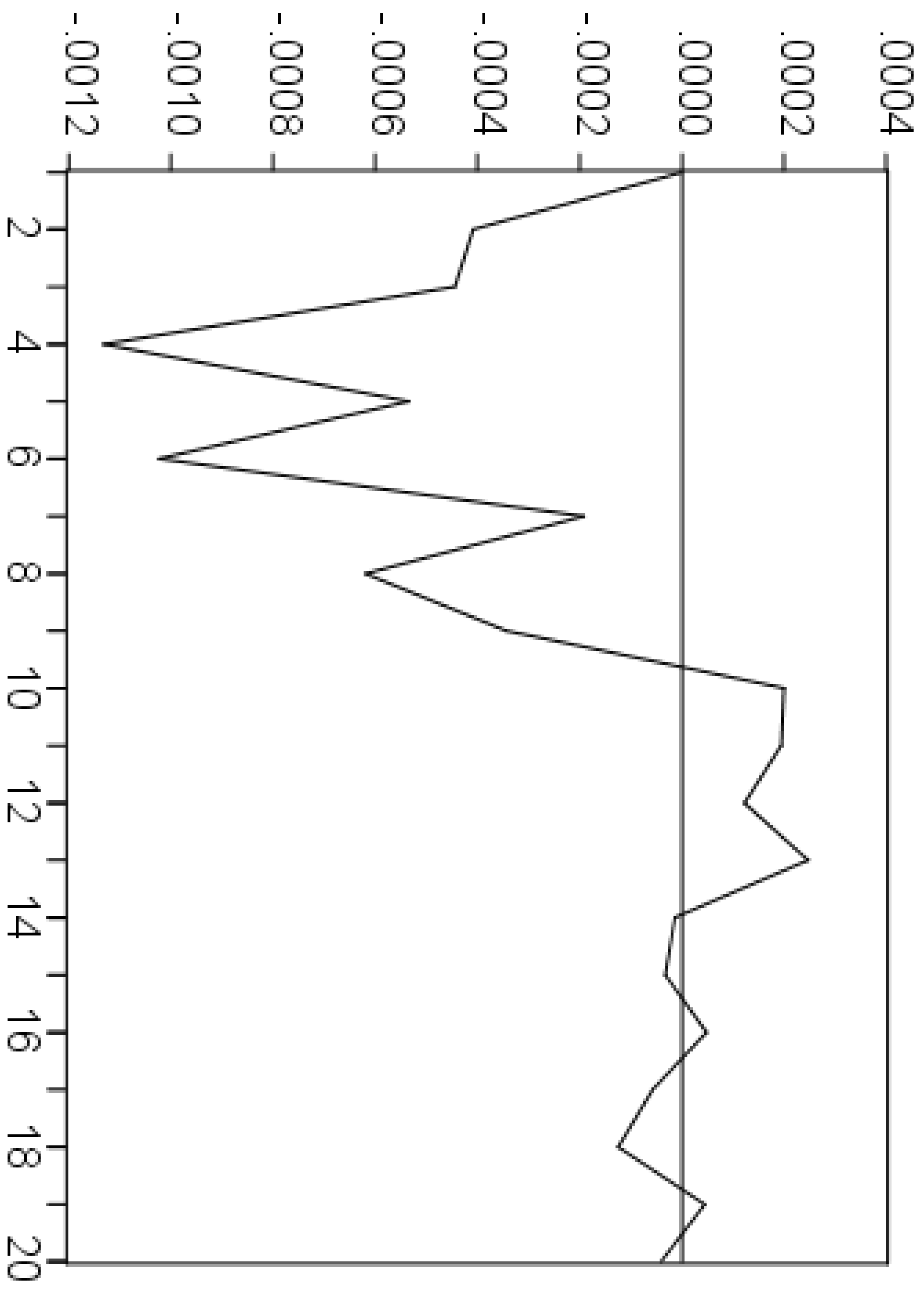
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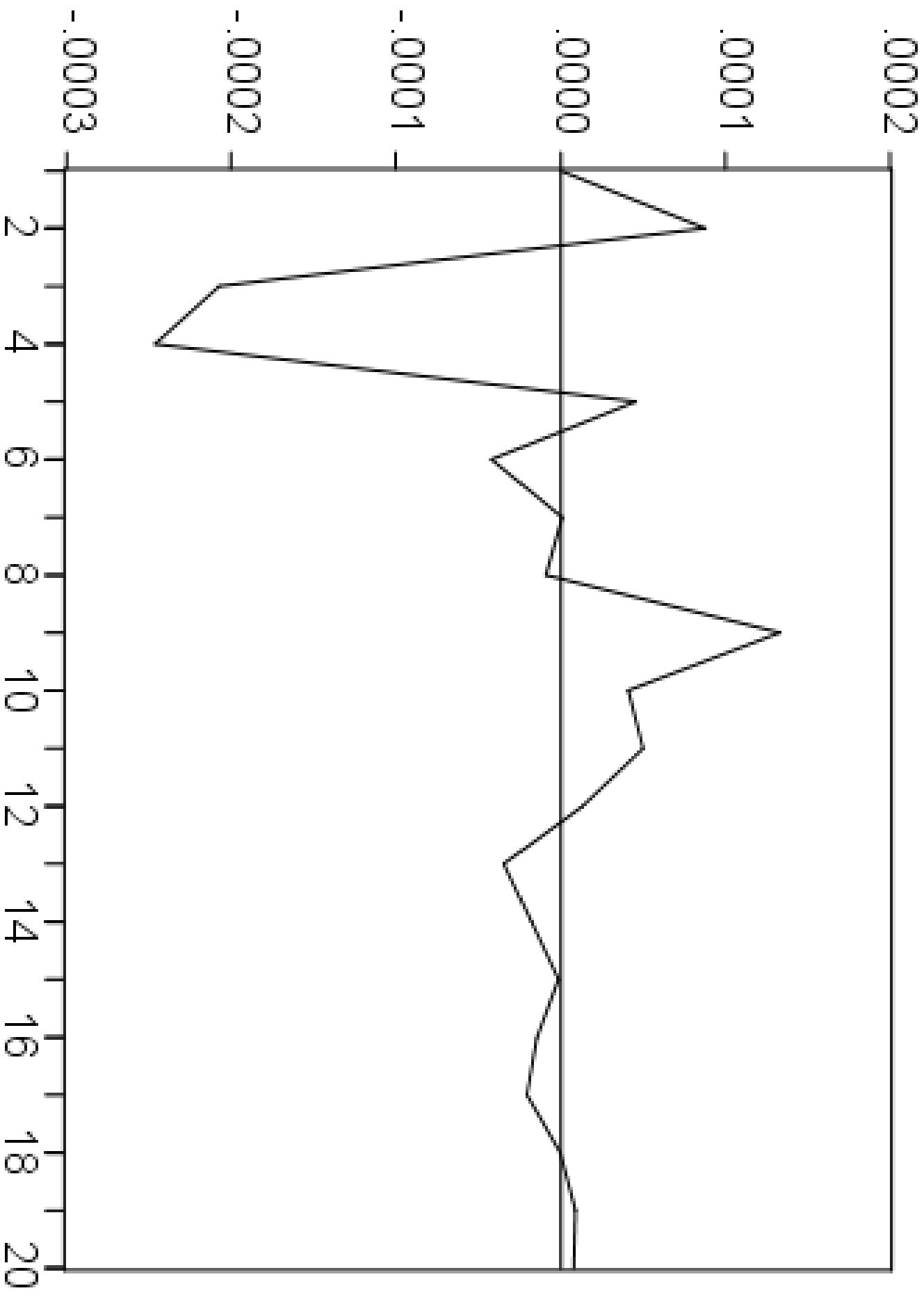
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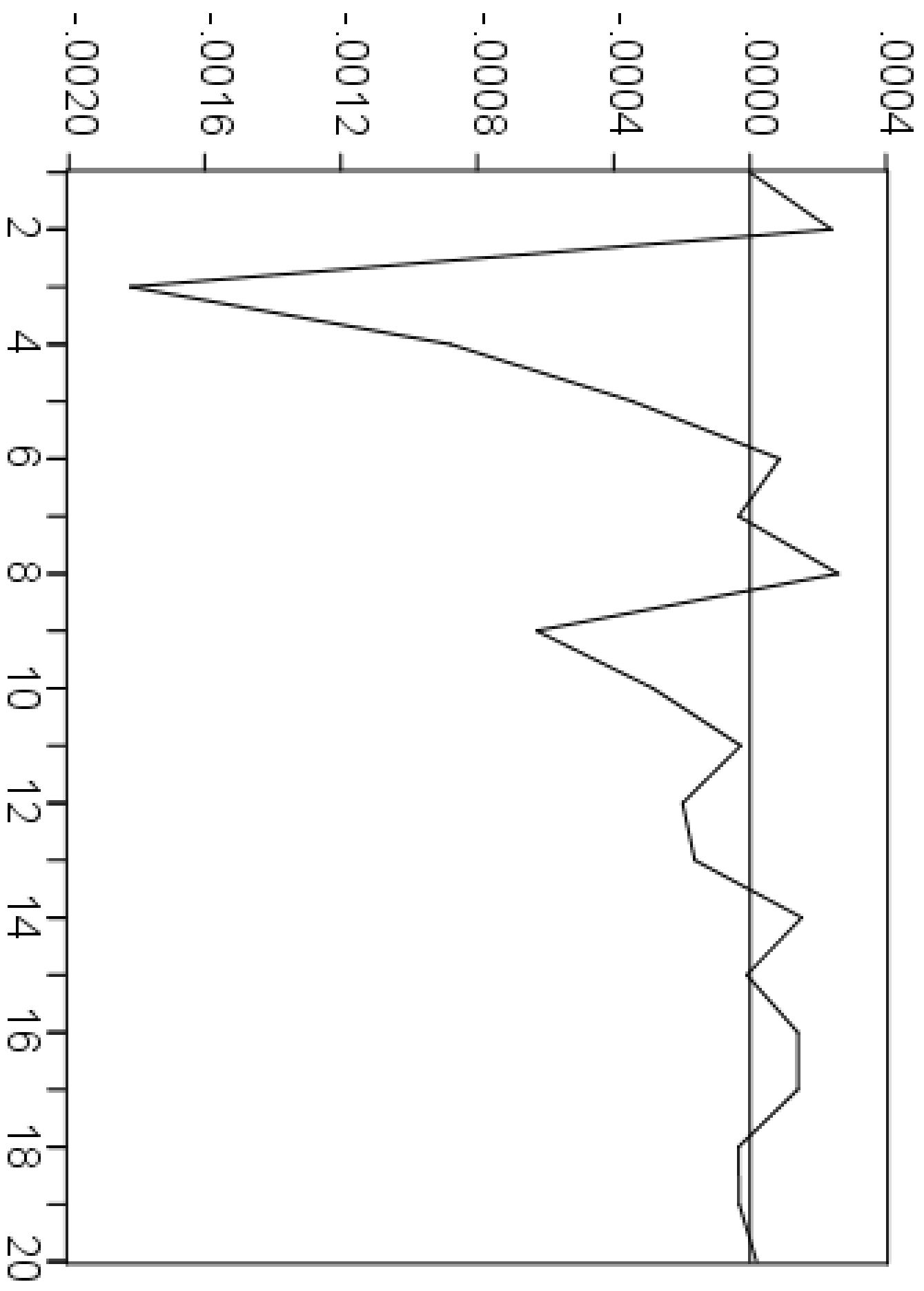
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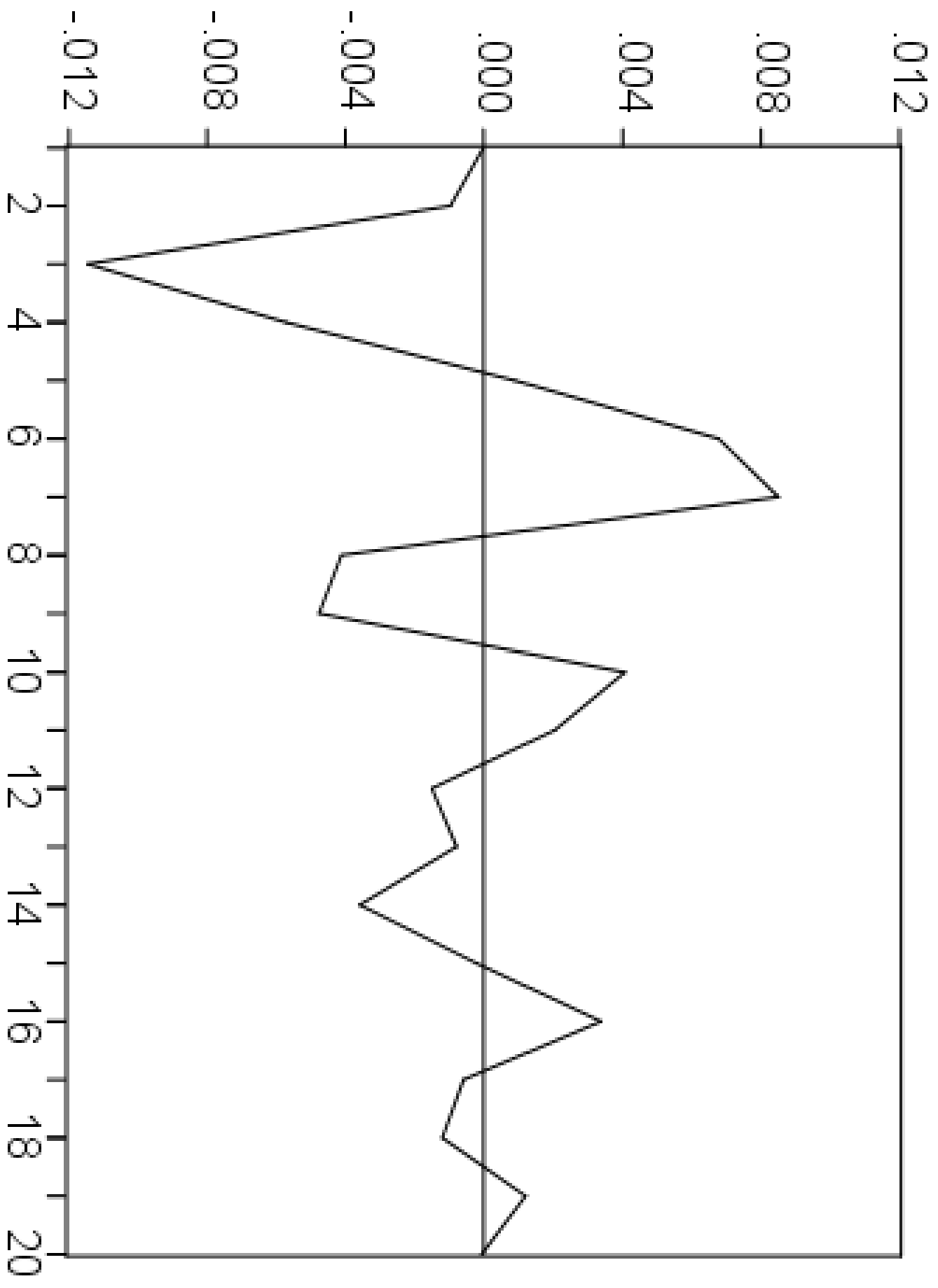
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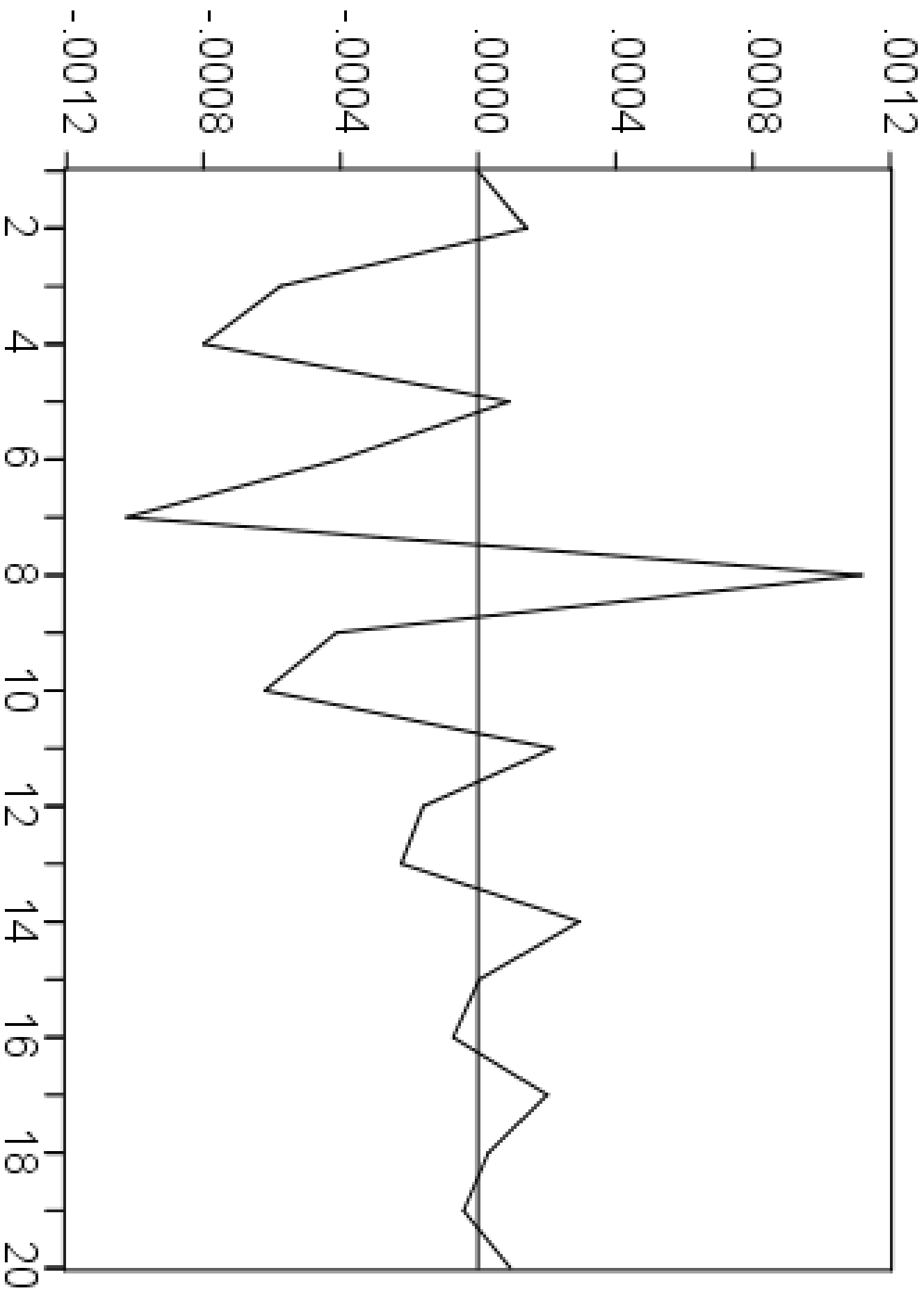
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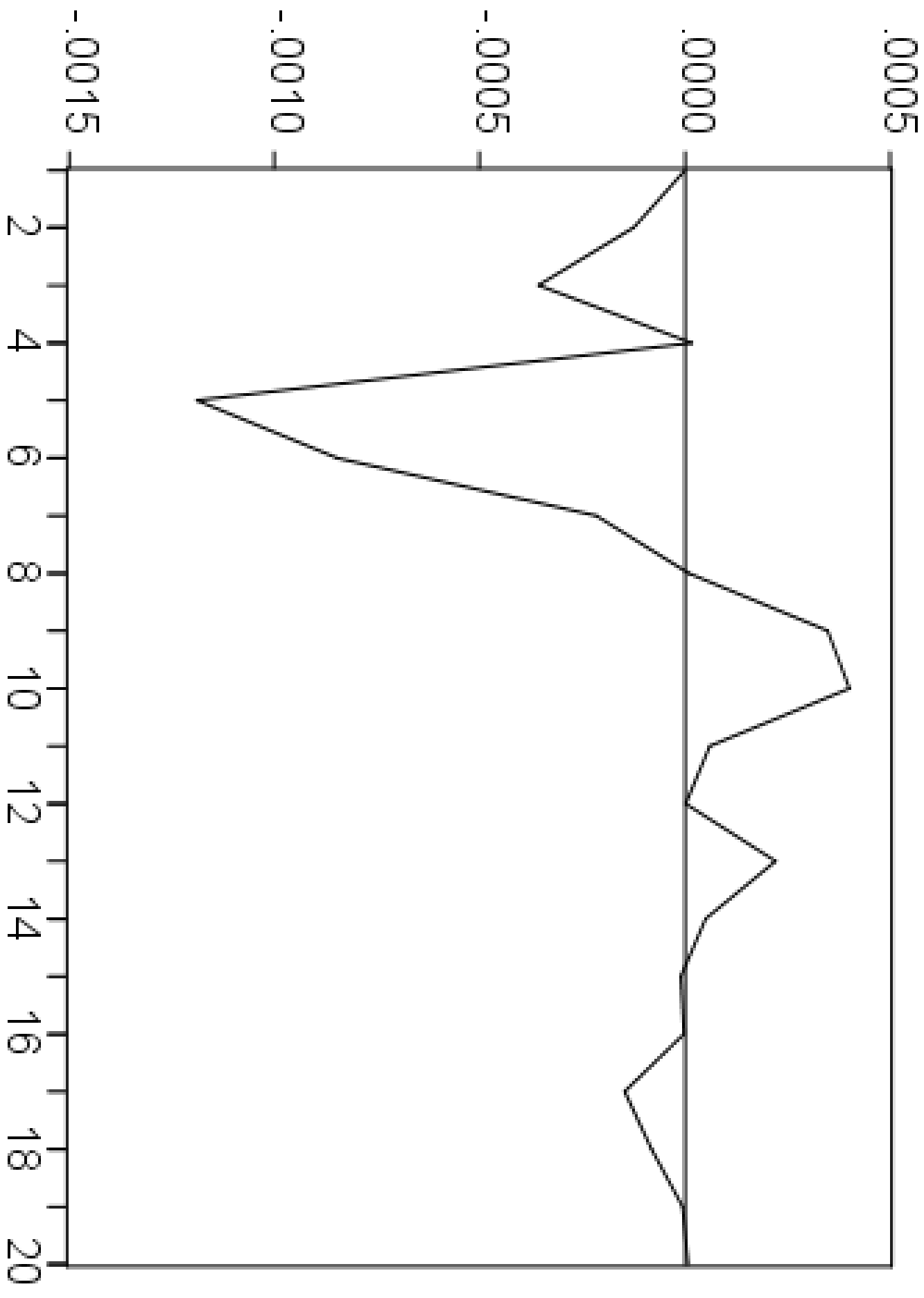
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Response of DLINVNONRESID_SA to Cholesky
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Response of DLEXP_SA to Cholesky One S.D. DLINT Innovation



Response of DLIMP_SA to Cholesky
One S.D. DLINT Innovation

