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Causal order between money, income and price through graph theoretic approach for Pakistan

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Abstract

We investigate the causal relationship between money, income and price for Pakistan using quarterly data from 1971-2003. We find that both money supply and prices cause income thus verifying the monetarists' point of view. Taking account of time series properties the methodology applies recent developments in graph theoretical causal search algorithms developed by Pearl, Glymour, Spirtes(1993) and Pearl(2000). One main merit of graph theoretic approach is that it overcomes problems of over identification in VAR models, Choleski decomposition on the other hand can only be applied for just an arbitrarily identified VAR models.

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1. Introduction

Money, income and price are some of the most important variables in the macro economy that are often monitored by economists and policy makers. The relationship between these variables has been subject of considerable debate to substantial research. There are basically two theoretical explanations linking money to price and income, namely Keynesians and Monetarists. The monetarist theory, based on the quantity theory of money, believes that direction of causation runs from money to income without any feedback, and Keynesians on the other hand stress that the direction of causation runs from income to money without any feedback .The conflict between the two schools of thoughts also exist over the relationship between money and prices. According to monetarists a continuous increase in prices is brought about by an increase in aggregate demand accompanied by increase in real output. This rise in aggregate demand is caused, according to monetarist, by an unnecessary expansion in money supply. Hence, money supply is the cause, and price is the effect. The Keynesians, on the other hand, view inflation as a real phenomenon caused by real factors.

In the light of this controversy Sims (1972) tried to find out the causal relationship between money and income. Sims found that the direction of causation runs from money to income without feedback and rejected the hypothesis that Granger causality is unidirectional from income to money as claimed by the Keynesians. Many subsequent studies provided mixed results. Williams et al; (1976) were dubious about Sims' results. They could not find clear evidence on the direction of Granger causality between money and income in UK. Their findings of Granger unidirectional causality operating from income to money, and from money to prices suggest that these three variables are determined jointly. Daniel and Batten (1985) found bidirectional Granger causality between money and income by using data from 1962:2 -1982:3. Bessler and Lee (2002) while using US data supported monetarist view that money causes price.

Hussain and Mahmood (1998) examined the causal relationship between money and prices in Pakistan. The analysis suggested a unidirectional causality running from money to prices. Bengali et al (1999) examined the direction of causation between money (both M_1 and M_2 definitions) and income variables, and between money and prices, in Pakistan using the Granger causality approach. With regard to the relationship between money (M1 and M2) and prices, unidirectional causality running from money to prices was found. Bidirectional causality was found between (M2) money and GDP, and between money and nonagricultural income. In the case of narrow money (M_1), however, bidirectional causality has been found between money and economic activity (GDP and its various components), and money and nonagricultural income both in the short run and in the long run. Ahmed(2003) attempts to investigate the issue of causality among money, interest rate, prices and output in selected South Asian Association for Regional Cooperation (SAARC) countries namely, Bangladesh, India, Pakistan. Bidirectional causality exists between money and prices in Bangladesh and Pakistan. For Bangladesh interest rate and money cause output and prices but vice versa is not true. The situation however is reversed for India and Pakistan. Hence role of money is more obvious in Bangladesh compared to Pakistan and India.

Most of these researchers have tried to resolve empirically this controversy between the structuralist and the monetarist by using Granger causality approach. In this regard several studies have been carried out both for developed and developing countries to test the direction of causation between money, income, and prices. However, the results of these studies, even for the same country have not been consistent and therefore, issue remains unresolved. These differences in empirical results stem in different methodological differences such as concept of money or price used, and importantly, the type of causality techniques/tests and lag-structures utilized.

Masih and Masih(1998) pointed out some drawbacks of the causality tests carried out in the past studies. These are

- There was no attempt at formally testing the null hypothesis of independence between the two series before any attempt at testing the direction of causality.
- Even if interdependence of the two series was established, since the two interdependent variables could be caused by a third factor, there was no formal test to rule out the possibility of no-causality between the two interdependent series.

- Although the direction of causality could be tested through the Granger and modified Sims tests only if the above two deficiencies are rectified, these tests ignore an additional channel of causation if the two variables are cointegrated. Intuitively, if two variables, say *x* and *y*, have a common trend (i.e. cointegrated), then the current change in *x* may be the result of *x* trying to move into alignment with the trend value of *y*. Such causality may not be detected by the standard Granger causality test which only examines whether past changes in a variable help explain current changes in another variable. In other words, there is the possibility that the lagged level of a variable, *y*, may help explain the current change in another variable, *x*, even if past changes in *y* do not. There is need, therefore, for a formal test of this additional source of causation that may exist if two variables have common trends. We would need, therefore, to make an attempt at improving on the above methodological deficiencies.[1]

We extend the previous works on causality by applying a graph theoretic approach. The graph-theoretic approach of causality was purposed Sprites et al. (1993) and Pearl (2000) among others. We have explored the causal relationship among money, income and prices for Pakistan by using a graph theoretic approach which is considered very scientific for detecting causal order among different time series variables. This will be discussed in methodology section. This effort to detect whether money causes income or vice versa by using econometric techniques in graph theoretic framework will make a valuable contribution in the literature on money, income and prices causal relationship.

The paper is organized as follows: In section two we introduce basic definitions and procedure for applying graph theoretic models to time series data. In section three we discuss data and time series properties of the variables. In particular we give the causal diagram to show relationship between the three variables. In the end we summarize our results and findings.

2. Methodology

The question of finding causal direction among money, price and income is addressed in this study by applying directed acyclical graphs (DAGs) to time series data on money, income and prices. DAGs allows us to invoke non-time sequence asymmetries between cause and effect for triples of variables, which helps us to uncover the causal relationship in contemporaneous time. Such causality is generally left uncovered in Granger-type definitions (see Granger1980).[2] The directed graphs literature is an attempt to infer causal relations from observational data.

[1] Masih and Masih(1998)

[2] Bessler and Lee(2002)

It is helpful to define some terminologies applied in graph theoretic approach. A structural model is represented by a graph in which arrows indicate the causal order, arrow head indicates the direction. A *directed graph* is a graph representing the causal flow among set of variables. The variables under consideration are called *Vertices*, the link showing the causal connection between pair of variables is called an *edge*. The link between two variables when direction of causation cannot be determined is called an *undirected edge* and the link which shows the direction of causation is called *directed edge*. If a variable A is connected to another variable B by an arrow originating at A and running into B, i.e. $A \rightarrow B$, then A is *ancestor* of B and B is called *descendent*, also A is the *cause* and B is *effect*. If there is no arrow directed from child to parent variable, then graph is called *acyclical graph*. An acyclical graph is a graph that contains no directed cyclical paths(an acyclical graph contains no variables more than once). Only acyclical graphs are used in this study. Suppose that $A \rightarrow B \rightarrow C$ (that is, A causes B causes C). A and C would be dependent, but conditional on B, they would be independent. Similarly for $A \leftarrow B \leftarrow C$. In each case, B is said to *screen* A from C. Suppose that $A \leftarrow B \rightarrow C$, A and C would be dependent, but conditional on B, they would be independent. B is said to be the *common cause* of A and C. *Collider* is a variable for which arrowheads are pointed toward it from both sides i.e $\rightarrow B \leftarrow$.

Suppose that A and B are independent conditional on sets of variables that exclude C or its descendants, and $A \rightarrow C \leftarrow B$, and also A and B are not directly connected. Then, conditional on C, if A and B becomes dependent, C will be called an *unshielded collider* on the path ACB. It is '*unshielded*' because there is no direct causal connection between A and B.

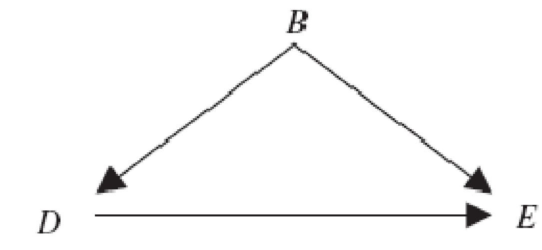

Figure 1

Vertex E is a *shielded collider* on the path DEB in Figure 1. The link B→D acts as a shield in that B and D are also connected by directed path even without conditioning on the E.

Large number of causal search algorithms has been developed and these algorithms start with the information about correlation among variables or any other test of conditional and unconditional statistical independence. These algorithms search for patterns of unshielded colliders, common cause, which are consistent with the observed correlations and finally results in a graph showing causal directions. One of the software which implements such algorithms is TETRAD. The most common of these algorithms is the PC algorithm which has been applied in this study. It assumes that graphs are acyclical or strictly recursive – that is, loops in which $\mathrm{A} \rightarrow \mathrm{B} \rightarrow C \rightarrow \mathrm{A}$ are ruled out.

Swanson and Granger (1997) provided a useful idea that graph theoretic methods could determine the contemporaneous causal order of the Structural Vector Autoregressive (SVAR) models when it is applied to the filtered variables. Swanson and Granger (1997) restricted to causal chains in which each contemporaneous variables could have one direct cause and they assumed that information about causal orderings of contemporaneous variables in SVAR was contained within the covariance matrix of the VAR error terms. Demiralp and Hoover (2003) extended their work by including recursive order and used PC algorithm in TETRAD. The algorithms in tetrad are data based search procedures in which search is carried out by multiple sequential testing. Working on the same lines, we explored the causal order among money, income and prices by using PC algorithm in TETRAD 4.3.2. Following are the steps of PC algorithm.

Hoover (2005) illustrates following steps of this algorithm.

(1) It starts with the complete set of variables in the VAR in which all variables are connected by undirected edges, i.e. a line without arrow head.

(2) It then tests for unconditional correlation among all pairs of variables, and removes any edge for which unconditional correlation is zero.

(3) Test for correlation among pair of variables conditioning on one other variable, again removes any edge for which conditional correlation vanishes .It then tests for conditioning on two, three variables until all variables are exhausted. This results in a skeleton.

Once skeleton is there, orientation of edges takes place in the following way.

(4) The algorithm starts orienting edges by seeking triples of linked $(A—\mathrm{B}—C)$ variables .For each conditionally uncorrelated pair of variables(i.e ones without a direct link)that are connected through third variables like (A—B—C) test whether they become correlated conditional on that third variable(B).This is the pattern of an unshielded collider, where (B) is unshielded collider. Orient the edges pointing toward unshielded collider $(A \rightarrow B \leftarrow C)$

(5) if two variables (A and B) are not directly connected, but are connected through a third variable (C), so that one link points to the third variable (say, $A \rightarrow C$) and the other link is undirected ($C—B$),then the undirected link is pointed away from third variable($C \rightarrow B$) This follows because, orienting the arrow toward C will make again unshielded collider which already completed in previous step.

(6) Some edges may be oriented logically (rather than statistically), based on maintaining the assumption of acyclicality and avoiding implying the existence of unshielded colliders not identified statistically.

In applications, Fisher's z statistics is used to test whether the conditional correlations are significantly different from zero.

3. Data and Results

Data for Pakistan is measured quarterly over the period1973:3-2003:2. We have used quarterly over the period1973:3-2003:2 for the variables; Money stock M2 as a measure of money, GDP as a measure of income, and Consumer Price Index CPI as a measure of price denoted by M,Y and P respectively. The nominal GDP is converted in real terms by deflating these series by GDP deflator and is denoted as **y**. All the variables are used in natural logarithmic form.

Prior to establish causal order among variables, it is necessary for the time series data to check whether variables on individual basis used for the study are stationary or not. To determine stationarity, we have used the Augmented Dickey-Fuller (ADF) unit root test. If a time series becomes stationary after differencing one time, then the time series is said to be integrated of order one I(1). Similarly, if a time series has to be differenced d times to make it stationary, then it is called integrated of order d I (d).The ADF test results for all the series are provided in Table (i) indicating that all the series are first difference stationary.

Table (i): ADF TEST REULTS

	ADF TEST STATISTIC		5% Critical Value
	LEVEL	-1.054638	-2.8857
MONEY	1ST DIFFERENCE	-11.36940(0)	-2.8859*
	2ND DIFFERENCE	--------	----------
PRICE	LEVEL	-1.869802	-2.8857
	1ST DIFFERENCE	-11.15972(0)	-2.8859*
	2ND DIFFERENCE	---------	-------
GDP	LEVEL	-0.929560	-2.8859
	1ST DIFFERENCE	-11.39860(1)	-2.8861*
	2ND DIFFERENCE		

Figures in brackets are the number of lag length selected.

Table (ii). VAR (2) Results

Sample(adjusted): 1974:2 2003:2
Included observations: 117 after adjusting endpoints
Standard errors & t-statistics in parentheses

	DM	DP	DY
DM(-1)	0.248475	-0.217610	-0.152114
	(0.27297)	(0.28034)	(0.18523)
	(0.91026)	(-0.77623)	(-0.82121)
DM(-2)	0.463523	-0.268151	-0.163081
	(0.27139)	(0.27872)	(0.18416)
	(1.70793)	(-0.96207)	(-0.88553)
DP(-1)	0.574351	-0.459650	0.093901
	(0.30495)	(0.31319)	(0.20693)
	(1.88340)	(-1.46764)	(0.45377)
DP(-2)	1.419291	-1.297813	-0.701048
	(0.27801)	(0.28551)	(0.18865)
	(5.10523)	(-4.54552)	(-3.71616)
DY(-1)	-0.526795	0.339802	-0.826082
	(0.19203)	(0.19722)	(0.13031)
	(-2.74322)	(1.72295)	(-6.33937)
DY(-2)	-0.422061	0.365102	0.144433
	(0.18059)	(0.18547)	(0.12254)
	(-2.33714)	(1.96857)	(1.17863)
C	-0.009863	0.039809	0.035397
	(0.01406)	(0.01444)	(0.00954)
	(-0.70142)	(2.75657)	(3.70957)

We find VAR (2) model Table (ii)) on differeced variables by using a lag length selection criteria based on AIC and SC. Therefore, we apply directed graphs to the innovations from VAR(2) on stationary data of money, income and price as the contemporaneous relationship is embedded in the innovations so residual matrix has been used for graph theoretic models. It is the matrix that provides the starting point for analysis of contemporaneous causation using directed graphs. Demirlap and Hoover (2003) have shown that PC algorithm is very efficient tool to recover the skeleton of data generating process (DGP) and intermediately effective to detect the direction of each causal link even though signal to noise ratios are high enough. As Sprites et al (2001) algorithms do not work directly for time-dependent data, so we use residuals obtained from VAR to prefilter the data to remove time dependence as suggested by Swanson and Granger (1997). We begin with a completely undirected graph shown in Figure 2. PC algorithm removes edges by considering the unconditional and conditional correlation between variables as shown in Figure 3. A 5% significance level is used for edge removal. Results of the PC algorithm are given in Figure 3 below.

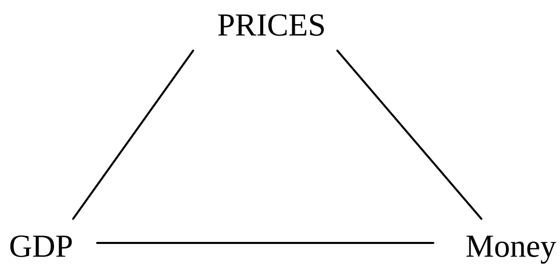

Figure 2

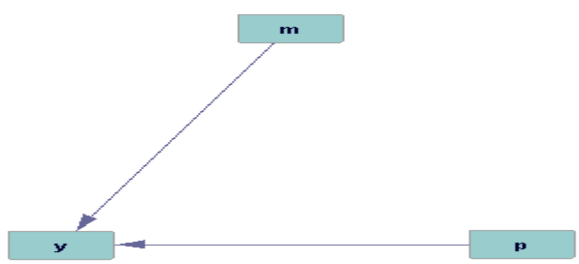

Figure 3

4. Results and Conclusion

By using quarterly data set available we have investigated the contemporaneous causal order by using graph theoretic models. We have applied PC algorithm to the innovations from VAR as contemporaneous correlation is embedded within the residual matrix of VAR. We find a unidirectional causality running from money to income and prices to income. These results are consistent with most of the previous studies carried out. This implies that a tight monetary policy may retard economic growth for a country like Pakistan which is already suffering very low economic growth rate for the last couple of years as compared to its neighboring countries India, China, Bangladesh etc. Prices cause income also is in agreement with the classical hypothesis that supply side helps in determining aggregate demand. Given very fragile economic situation of Pakistan, it can ill afford for a very big fiscal stimulus like those of developed countries.

State Bank of Pakistan is observing tight monetary policy to control inflation but tight monetary policy (high interest rate with little credit available) may bring down the economy which slid down into deep recession and depression. Therefore, somewhat relaxed monetary policy is necessary to boost economic growth. It is high time to take bold economic decisions useful for our economy in the long run rather just meeting stringent conditions laid down by the lending agencies.

References

Ahmed, M., (2003),"Money-Income and Money-Price Causality in selected SAARC Countries: Some Econometric Exercises" The Indian Economic Journal, Vol 50, No.1, Pp55-62.

Bengali, K., K.H. Ashfaque., and M. Sadaqat., (1999)," Money, Income, Prices, and Causality: The Pakistani Experience" The Journal of Developing Areas, Vol. 33, No. 4, Pp: 503-514.

Bessler, D.A., and S. Lee., (2002) "Money and prices: US data 1869–1914 (a study with directed graphs)", Empirical Economics, Vol. 27, Pp: 427–446.

Daniel, L. T., and D.S. Batten., (1985) "Lag-Length Selection and Tests of Granger Causality between Money and Income" Journal of Money, Credit and Banking, Vol. 17, No. 2, Pp: 164-178.

Demiralp,S., and K.D.Hoover., (2003) "Searching for the causal structure of a vector auto regression" Oxford Bulletin of Economics and statistics, 65, Supplement Pp:745-767.

Demiralp S., K.D. Hoover., and P.J. Stephen., (2008) "A Bootstrap Method for Identifying and Evaluating a Structural Vector Autoregression" Oxford Bulletin of Economics and Statistics, 70: Pp: 509–533.

Hoover, K.D., (2005) "Automatic Inference of Contemporaneous Causal Order of a System of Equations" Econometric Theory 21(1), Pp: 69-77.

Hussain, F., and T. Mahmood., (1998)," Causality between Money and Prices: Evidence from Pakistan", The Pakistan Development Review 37: 3 Part II (Winter 1998), Pp. 37:4, 1155–1161.

Granger, C.W.J., (1980) "Testing for causality: A personal viewpoint" Journal of Economic Dynamics and Control 2, 329-352.

Masih A.M.M., and R. Masih., (1998)," Does money cause prices, or the other way around? Multi-country econometric evidence including error-correction modeling from South-east Asia" Journal of Economic Studies, Vol: 25 Number: Pp: 138-160.

Pear, J., (2000) Causality: Models, Reasoning and Inference. Cambridge University Press

Sims, C.A., (1972). 'Money, Income and Causality', American Economic Review, Vol. 62, Pp: 540-552.

Spirtes, P., Glymour, C. and Scheines, R. (1993). *Causation, Prediction, and Search,* New York, N.Y.: Springer-Verlag. 2nd Edition, MIT Press (2001)

Swanson N.R., and C.W.J. Granger., (1997)"Impulse Response Functions Based on a Causal Approach to Residual Orthogonalization in Vector Autoregressions" Journal of the American Statistical Association, Vol. 92, No. 437, Pp: 357 -367.

Williams, W., C. Goodhart., and D. Gowland., (1976), "Money, Income, and Causality: The U.K. Experience" American Economic Review, June, Pp: 417–423.