Inter-Level Causal Reasoning in Stock Price Index Prediction Model

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Abstract

This paper proposes inter-level causal reasoning to implement synergistic approach. We decompose KOSPI prediction model into economy and industry level. Two kinds of intra-level QCOM are combined in inter-level QCOM via inter-level relations. Downward reasoning is achieved by propagating the disturbance in the higher level to lower level while upward reasoning is to analyze the reverse cases.

1. Introduction

Causal ordering techniques are developed to build qualitative models and to investigate causal dependencies of qualitative models. The pioneering work on causal ordering techniques was Simon's causal ordering (1953). The essentially equivalent, but more intuitive, component-based confluence analysis of De Kleer and Brown (1984) does not order variables in accordance with causality. Instead, the model structure is interpreted by propagating a given change through causes and effects. The causal-ordering graph (Berndsen, 1995) is a graphical representation of causal ordering.

Causal reasoning has been traditionally used to understand the structure and behavior of ordered qualitative models. However, qualitative causal reasoning is not appropriate in areas where precise quantitative information is required because the concept of causal ordering techniques is qualitative. This paper proposes inter-level causal reasoning to introduce a framework to combine qualitative and quantitative reasoning and the more rigorous reasoning that is capable of upward/downward reasoning. In contrast to qualitative causal reasoning, the proposed inter-level causal reasoning is operated in a quantitative model, Korea stock price index (KOSPI) prediction model derived by quantitative causal ordering map (QCOM).

KOSPI prediction model is decomposed into multi-levels so that this leads to inter-level or intra-level QCOM, both economy and industry level QCOM. Two kinds of intra-level QCOM are inter-related through inter-level relations and combined in inter-level QCOM, where inter-level causal reasoning can be simulated. With the inter-level QCOM, the changes in variables in economy level can is propagate into not only other variables in its own level, but also variables in industry level via inter-level relations, and vice versa. Therefore, the proposed causal reasoning can be expressed in terms of two kinds of reasoning: (1) intra-level reasoning and (2) inter-level reasoning. Intra-level reasoning is introduced in Kim & Han (1998), in this paper, we will demonstrate inter-level reasoning.

The structure of this paper is as followings. In next section, the construction procedure of QCOM for KOSPI prediction model is introduced. Inter-level causal reasoning in static and dynamic model is described in section 3. In section 4, conclusion and directions for future research are presented.

2. Quantitative Causal Ordering Maps for KOSPI Prediction Model

QCOM, an improved version of causal-ordering graph (Berndsen, 1995), is developed to encompass quantitative as well as qualitative reasoning so that causal reasoning based on this technique generates numerical multipliers and symbolistic explanations. To trigger inter-level causal reasoning, we need not only two kinds of intra-level QCOM but also inter-level QCOM, wherein two kinds of intra-level QCOM are inter-related with each other.

Economy level QCOM is based on an economic theory (Han & Seo, 1995). Nine economic factors are used in the prediction of composite stock price index of next month ($CSPI_{+1}$) as endogenous variables, including BCA (balance of current account), EPI (export price index), GNP (gross nation production), CPI (consumer price index), WPI (wholesale price index), W (monthly average wage), ER (exchange rate), IPI (export price index), IR (interest rate). The exogenous variables are M2 (M2 average), ER_{-1} (exchange rate of last month), IR_{-1} (interest rate of last month) and GNP_{-1} (GNP of last month).

Industry level QCOM concerns industrial stock price index movement. A various investment theories (Haugan, 1990) have regarded several kinds of business survey index (BSI) as one of the most important factors that might affect industrial stock price index behaviors. Eight BSIs and two lagged variables are used to predict industrial stock price index of next month of automobile ($SPIAI_{+1}$) and ship construction industry ($SPISCI_{+1}$). They are domestic demands BSI, exports BSI, employment conditions BSI, fund conditions BSI and industrial stock price index of current month of automobile (denoted as DDAI, EXAI, ECAI, FCAI, SPIAI sequentially) and ship construction industry (denoted as DDSCI, EXSCI, ECSCI, FCSCI, SPISCI). Nine kinds of inter-relations are obtained from experts because there was no literature to explore the causality among variables in economy and industry level. The set of variables and relations in intra-levels and inter-level are described in Table 1

Table 1. The Set of Variables and Relations

Variables	Set of Relations
$CSPI_{+1}$	r1 ($CSPI_{+1}$, GNP, IR)
BCA	r2 (BCA, EPI, IPI)
IR	r3 (IR, GNP, GNP_{-1}, M2, IR_{-1})
EPI	r4 (EPI, GNP, ER, IPI, W)
GNP	r5 (GNP, W, IPI, ER, ER_{-1}, M2)
CPI	r6 (CPI, GNP, GNP_{-1})
WPI	r7 (WPI, CPI)
W	r8 (W, WPI)
ER	r9 (ER, BCA, ER_{-1})
IPI	r10 (IPI, ER)
M2	r11 (M2)
ER(-1)	r12 (ER_{-1})
IR(-1)	r13 (IR_{-1})
GNP(-1)	r14 (GNP_{-1})

(a) Economy Level Relations

Variables	Set of Relations
$SPIAI_{+1}$	r15 ($SPIAI_{+1}$, DDAI, EXAI, ECAI, FCAI)
DDAI	r16 (DDAI)
EXAI	r17 (EXAI)
ECAI	r18 (ECAI)
FCAI	r19 (FCAI)
$SPISCI_{+1}$	r20 ($SPISCI_{+1}$, DDSCI, EXSCI, ECSCI, FCSCI)
DDSCI	r21 (DDSCI)
EXSCI	r22 (EXSCI)
ECSCI	r23 (ECSCI)
FCSCI	r24 (FCSCI)
SPIAI	r25 (SPIAI)
SPICSI	r26 (SPISCI)

(b) Industry Level Relations

Variables	Set of Relations
EPI	r27 (EPI, EXAI , EXSCI)
IR	r28 (IR, FCAI, FCSCI)
$CSP_{+1}I$	r29 ($CSPI_{+1}$, $SPIAI_{+1}$, $SPISCI_{+1}$)
EXAI	r30 (EXAI, EPI)
EXSCI	r31 (EXSCI, EPI)
FCAI	r32 (FCAI, IR)
FCSCI	r33 (FCSCI, IR)
$SPIAI_{+1}$	r34 ($SPIAI_{+1}$, $CSPI_{+1}$)
$SPISCI_{+1}$	r35 ($SPISCI_{+1}$, $CSPI_{+1}$)

(c) Inter-Level Relations

QCOM is developed in a manner as following three phases: (1) the model graph, (2) the causal-ordering graph, and (3) quantitative causal ordering map. Refer to Kim & Han (1998). Figure 1 shows the model graph and the perfect matching, where each link of the perfect matching is denoted as a bold line. Inter-level QCOM is obtained from the causal-ordering graph by applying path analysis to historical instances. We collect the monthly data set for 72 months from January 1990 to December 1995. Based on the Two-Stage Least Squares parameter estimates of inter-level QCOM, inter-level QCOM and two kinds of intra-level QCOM with numerical causal coefficients are represented in Figure 2, where, solid links, bold links and dot links indicate economy level relations, industry level relations and inter-level relations respectively.

Figure 1. Model Graph and Perfect Matching

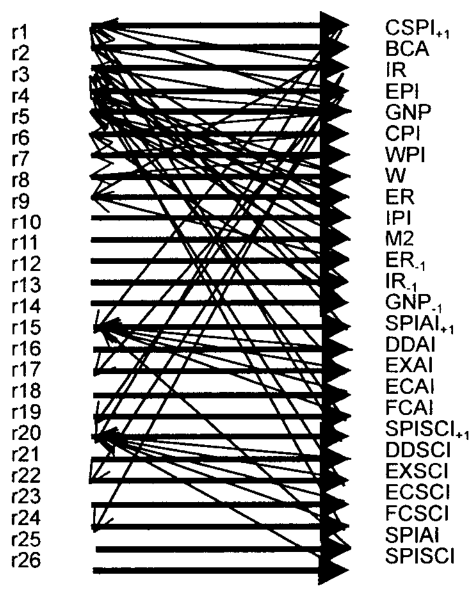
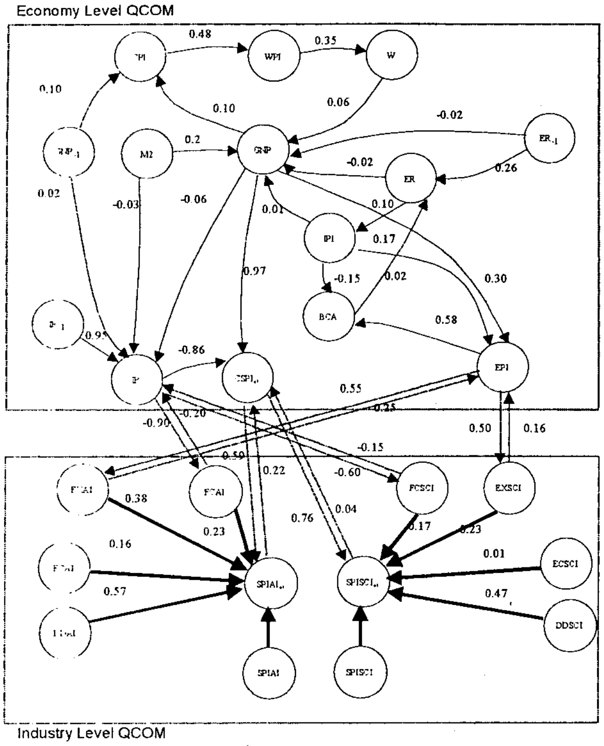


Figure 2. Quantitative Causal Ordering Map

3. Inter-level Causal reasoning

3.1 Downward Causal Reasoning

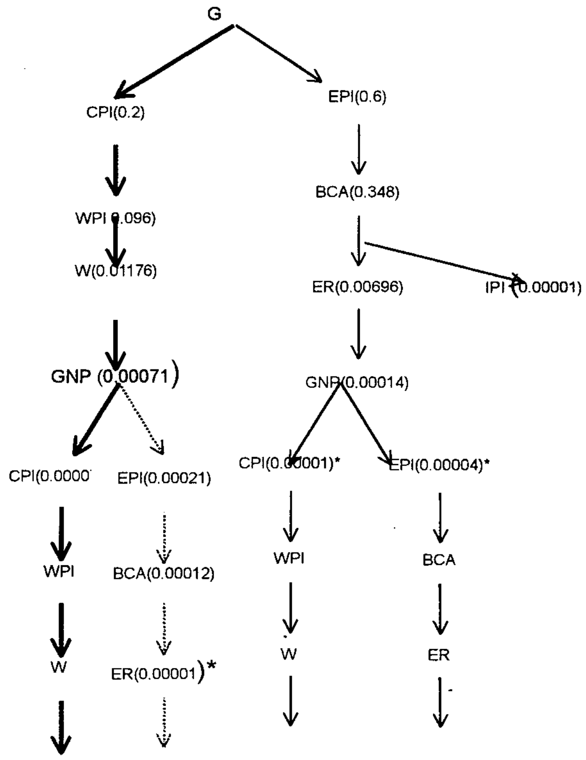
In economy level QCOM, we can propagate the disturbance of exogenous variables along the cycles. Let us illustrate economy level causal propagation in a cycle circulating GNP, CPI, WPI, W, and GNP (GNP $\rightarrow$ CPI $\rightarrow$ WPI $\rightarrow$ W $\rightarrow$ GNP). The changes in GNP affects CPI, WPI, W and GNP in sequence, yielding the changes in the corresponding variables. This causal propagation process is continued until a



convergence threshold (herein, 0.0001) is attained, accumulating the changes for the variables involved each time around the cycles. This process is graphically represented as economy level causal tree in Figure 3, wherein the path of this repetitive causal propagation is denoted as bold lines. After completing causal propagation in bold-lined branch, the propagation process is continued in the neighboring branch GNP → EPI → BCA → ER → GNP presented as the dot lines in Figure 3 until a convergence threshold is realized. In a similar manner described above, this propagation process is applied to all branches of causal tree. For better understanding, suppose that there is the increase in M2 by 10. This disturbance traverses through the causal tree, yielding the changes in variables visited. Figure 6 shows the results of causal propagation due to the changes in M2, where the contents of parenthesis and asteroid mark in Figure 3 mean static multipliers and breaking point of causal propagation in a given branch.

The changes in endogenous variables IR and $CSPI_{+1}$, which is not involved in cycles, is computed once after completing causal propagation in all of the branches. The changes noted for variables in economy level propagates downward to industry level through inter-level relations (from $CSPI_{+1}$ to $SPIAL_{+1}$ and $SPISCL_{+1}$, from EPI to EXAI and EXSCI, and from IR to FCAI and FCSCI) thereby triggers the changes in $SPIAL_{+1}$ and $SPISCL_{+1}$.

Figure 6. Causal Tree



Dynamic simulation is obtained by introducing causal relations between time periods. The Changes due to each of the lagged variables propagates the same way as done in the static model. In KOSPI prediction model, dynamic simulation is achieved by assigning the accumulated changes of lagged endogenous variables GNP, ER, IR for the previous time periods to GNP_{-1}, ER_{-1}, and IR_{-1} respectively

Table 2 presents the summarized results of causal reasoning about 20 units increase in M2. Based on the results of Table 2, we can conclude that the increase in M2 positively affects $CSPI_{+1}$ as well as $SPIAL_{+1}$ and $SPISCL_{+1}$, however, the effect of M2 on these variables is decreasing as the time evolves. The results of static and dynamic propagation are close to those obtained from the matrix solution method. This demonstrates that the proposed technique generates results consistent with those generated from traditional numerical technique.

Table 2. The result of downward reasoning

Variable	Time period 0	1	2	3
GNP	4.0038	0.0037	-0.0001	0.0000
EPI	1.2014	0.0012	0.0000	0.0000
BCA	0.6966	0.0006	0.0000	0.0000
ER	0.0139	0.0036	0.0009	0.0002

IPI	0.0014	0.0004	0.0001	0.0000
CPI	0.4004	0.4007	0.0004	0.0000
WPI	0.1922	0.1924	0.0002	0.0000
W	0.0673	0.0673	0.0001	0.0000
IR	-0.8402	-0.7184	-0.6824	-0.6482
$CSPI_{+1}$	4.6063	0.6214	0.5867	0.5575
FCAI	0.7562	0.6465	0.6141	0.5834
EXAI	0.6608	0.0006	0.0000	0.0000
ECAI	0.0000	0.0000	0.0000	0.0000
DDAI	0.0000	0.0000	0.0000	0.0000
FCSCI	0.5041	0.4310	0.4094	0.3889
EXSCI	0.6007	0.0006	0.0000	0.0000
ECSCI	0.0000	0.0000	0.0000	0.0000
DDSCI	0.0000	0.0000	0.0000	0.0000
$SPIAI_{+1}$	3.1427	0.5156	0.4874	0.4631
$SPICSI_{+1}$	3.7246	0.5456	0.5155	0.4898
SPIAI	0.0000	0.0000	0.0000	0.0000
SPICSI	0.0000	0.0000	0.0000	0.0000

4.2 Upward Causal Reasoning

Upward causal reasoning refers to the upward evolved causal reasoning from industry level QCOM to economy level QCOM. To trigger upward causal reasoning, let us assume that two exogenous variables (EXAI and FCSCI) are disturbed. This disturbance affects $SPIAI_{+1}$ and $SPISCI_{+1}$ in industry level at first and thus propagates upward to variables in economy level via inter-relations (from EXAI to EPI, FCSCI to IR, from $SPIAI_{+1}$ and $SPISCI_{+1}$ to $CSPI_{+1}$). In economy level, propagating changes is achieved by applying economy level reasoning process described above. Meanwhile, Dynamic analysis is achieved by propagating lagged endogenous variables ($SPIAI_{+1}$ and $SPISCI_{+1}$) carried from the previous time periods

In Table 3, we present the analysis for combined change, 10 units increase in both EXAI and FCSCI, for up to three time periods. The results of upward reasoning, similar to that of downward reasoning, shows that the changes in industry level affects not only its own level but also the upper level.

Table 3. The results of upward reasoning

Variable	Time period			
	0	1	2	3
GNP	4.0038	0.0037	−0.0001	0.0000
EPI	1.2014	0.0012	0.0000	0.0000
BCA	0.6966	0.0006	0.0000	0.0000
ER	0.0139	0.0036	0.0009	0.0002
IPI	0.0014	0.0004	0.0001	0.0000
CPI	0.4004	0.4007	0.0004	0.0000
WPI	0.1922	0.1924	0.0002	0.0000
W	0.0673	0.0673	0.0001	0.0000
IR	−0.8402	−0.7184	−0.6824	−0.6482
$CSPI_{+1}$	4.6063	0.6214	0.5867	0.5575
FCAI	0.7562	0.6465	0.6141	0.5834
EXAI	0.6608	0.0006	0.0000	0.0000
ECAI	0.0000	0.0000	0.0000	0.0000
DDAI	0.0000	0.0000	0.0000	0.0000
FCSCI	0.5041	0.4310	0.4094	0.3889
EXSCI	0.6007	0.0006	0.0000	0.0000
ECSCI	0.0000	0.0000	0.0000	0.0000
DDSCI	0.0000	0.0000	0.0000	0.0000
$SPIAI_{+1}$	3.1427	0.5156	0.4874	0.4631
$SPICSI_{+1}$	3.7246	0.5456	0.5155	0.4898
SPIAI	0.0000	0.0000	0.0000	0.0000
SPICSI	0.0000	0.0000	0.0000	0.0000

4. Conclusion Remarks

This paper proposes inter-level causal reasoning to implement synergistic approach which can solve the complex problems such as KOSPI prediction problem. We decompose KOSPI prediction model into economy and industry level to perform economy and industry analysis. This leads to two kinds of intra-level QCOM, economy and industry level QCOM. Two kinds of intra-level QCOM are combined in inter-level QCOM via inter-level relations. Inter-level contains downward/upward reasoning. Downward reasoning is achieved by propagating the disturbance in the higher level (herein, economy level) to lower level (herein, industry level) while upward reasoning is to analyze the reverse cases.

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