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# **A Knowledge Based System for Investment Advice**

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## Table of Contents

<b>1</b>	<b>Introduction to the Domain - Investment Advice</b>	<b>1</b>
1.1	Factors Affecting Investment Choice . . . . .	1
1.2	Types of Investment . . . . .	2
<b>2</b>	<b>Knowledge Sources and Elicitation Methods</b>	<b>2</b>
2.1	Sources . . . . .	2
2.2	Methods . . . . .	3
<b>3</b>	<b>Intermediate Knowledge Representation</b>	<b>4</b>
3.1	Risk Portfolio Assessment . . . . .	4
3.2	Duration Portfolio Assessment . . . . .	5
3.3	Investment Direction Advice . . . . .	5
<b>4</b>	<b>Knowledge Representation Using Rules</b>	<b>7</b>
<b>5</b>	<b>Knowledge Representation using CLIPS Rules</b>	<b>7</b>
<b>6</b>	<b>Test Problems</b>	<b>7</b>
6.1	Test Problem 1 - Young Daredevil . . . . .	7
6.2	Test Problem 2 - Middle Aged Hard Worker . . . . .	8
6.3	Test Problem 3 - Retired Businessman . . . . .	8
<b>7</b>	<b>Usage Instructions</b>	<b>9</b>
<b>8</b>	<b>Limitations and Regrets</b>	<b>9</b>
	<b>References</b>	<b>9</b>
	<b>Appendices</b>	<b>9</b>
<b>A</b>	<b>CLIPS Rules</b>	<b>9</b>

## List of Tables

1	Questions for risk assessment. . . . .	5
2	Decision table for risk portfolio assessment. . . . .	6

3 Decision table for investment direction advice. . . . . 7

# **1 Introduction to the Domain - Investment Advice**

Most people want to invest their money at some stage in their life. But they find it very difficult to decide what to invest in because they have no experience in investing! Therefore they need help from others in order to decide upon the right investment choice because the investment field is a domain in which knowledge is vital to success. The knowledge based system developed for this assignment aims to guide people in a general investment direction based upon the answers that they provide to the questions asked by the system. The system works on the domain knowledge described in the following sections.

## **1.1 Factors Affecting Investment Choice**

At any point in time, investment choice can be affected by a large number of factors like inflation, economic growth, interest rates and exchange rates. But investment choices cannot be made using these factors because they can fluctuate rapidly. Instead, investment choices are first based on the requirements of the investor. After a general choice is made, the other factors are taken into consideration before choosing a specific investment. The knowledge based system developed for this assignment deals with the general investment choice. The factors that affect that choice are as follows[2, 3]:

### **Duration**

This is the duration for which the investor is willing to invest his/her money in the investment. It is broadly classified into 1-3 years (Short Term), 3-7 years (Medium Term) and more than 7 years (Long Term). Usually long term investments generate higher returns than shorter term investments.

### **Returns**

Returns is the profits which the investor wants to make from the investment. Higher returns usually require higher risk and sometimes lower liquidity. This also about the type of returns required. Returns can be through income or growth. Income is a regular flow of money which the investor can use. Growth is increase in the money put into the investment.

### **Liquidity**

Liquidity is the ease with which the money invested in an investment can be converted to cash when required.

### **Risk**

This is the amount of risk that the investor is willing to accept or can accept. It depends on a large number of factors like age, income, job security and goals.

It is easy to see that most of the factors are interdependent on each other. Most factors are directly related to risk with returns being the most dependant. Liquidity is directly dependant on duration. Therefore in order to avoid users entering conflicting information, the system developed only considers risk and duration before providing advice. This does not reduce the reliability of the advice because returns are directly dependant on risk and liquidity is directly dependent on duration.

## 1.2 Types of Investment

There are a large number of different types of investments, but all of them generally fall under the following categories[3, 2]:

### Fixed Term Bank Deposits

This is the most well known form of investment. The investor just deposits his/her money in a bank and the bank gives interest for the deposited money. Bank deposits are very low risk investments and have very high liquidity. The investor has immediate access to the money invested in bank deposits. As a result, the returns are very low. Higher returns can be obtained by increasing the terms of deposits. But this reduces the liquidity and returns maybe reduced if money is withdrawn before the end of the term.

### Bonds

Bonds are similar to bank deposits but the investor deposits his/her money with an organization other than a bank (industry for example). The organization in turn promises to return the money after a fixed term and pay interest at a fixed rate. Bonds have higher risk since the organization is not a bank. As a result, they have higher returns(interest rates). Bonds have lesser liquidity than bank deposits because money cannot be withdrawn from a bond before the term expires. But bonds themselves can be sold to obtain money.

### Property

This refers to real estate property. It is a medium to high risk investment because prices can fluctuate rapidly and profits are not guaranteed. Careful thought and analysis has to be performed before investing in a particular property. As a payback for the high risks, the returns can be very high as well. But in most cases only long term investment will generate high profits. Liquidity is low because it can take quite a while to sell real estate property. But returns can be obtained through other means such as renting.

### Shares

This is the most high risk and high return investment option. The risk is higher than the property market because real estate prices are much more predictable than share prices. As a result, the returns also tend to be higher. This option provides more liquidity than the property market because shares can be sold with greater ease than real estate property. Like in real estate, in most cases only long term investment will generate high returns.

## 2 Knowledge Sources and Elicitation Methods

### 2.1 Sources

The knowledge base for the developed system was obtained from three main sources as follows:

#### Sorted[3]

A financial advice web-site maintained by the New Zealand government and the Re-

tirement Commission in particular. This web-site provided knowledge about the types of investment and the factors involved in creating an investment profile for an investor.

### **Wall-Street Journal[2]**

A financial advice book written from the famous Wall-Street Journal. This book had very useful information about the different types of investments and about who should choose which investment.

### **Long Time Personal Investor**

The investor has been successfully investing money in all the major types of investments mentioned for more than ten years. He provided critical information about how he has been making his investment decisions.

## **2.2 Methods**

The knowledge based system was developed by closely following the process described in [1] for developing a small knowledge system. While selecting the problem, the following were taken into consideration:

- The problem can be solved by an individual in less than 30 minutes. Financial advisors can advise a person on what to invest in about 30 minutes.
- The problem has to be rule based. Investment choices are naturally rule based because choices are made according to the criteria required by the investor. Therefore the problem can easily be transferred into a rule based system with rules for dealing with the various criteria considered while making investment choices.
- The system should require less than 200 rules. There are a large number of criteria which affect investments, if all these criteria were taken into account, it would be impossible to have less than 200 rules. Therefore the problem was restricted to providing general investment direction guidance rather than specific investment recommendation. This made it possible for the system to be implemented with less than 100 rules.

While acquiring and modeling the knowledge for the selected problem, the following methods were used:

### **Task Analysis**

During this phase, the specific task that will be performed by the system was identified. The system would be used by investment novices to determine a general investment direction rather than providing specific advice to experienced investors. This decision was made in order to reduce the size of the knowledge base and because novice investors have a greater need and greater use for a knowledge based investment advice system than experienced users. The questions for the rules were structured in such a way that they could be easily understood by the targeted users.

### **Preliminary Study**

Preliminary knowledge about the problem was obtained from [3] and [2]. The factors that affect investment decisions and the different types of investments were identified. Rules connecting the factors to the investment types were also obtained from these sources.

### **Interviews**

Interviews were conducted with the Personal Investor in order to find out how he made his investment decisions. He was asked questions regarding how each of the identified factors affected his investment decisions. His answers were captured using rules and were also verified with the rules obtained from the preliminary study. Through the interviews, information was also obtained about the options that should be provided for answering the questions and the weighting that should be given to each option. Finally the investor was provided with the test cases and his solutions were compared with the solutions that would be generated by an inference system running on the knowledge base.

### **Decision Tables**

Decision tables were used to model the knowledge captured from the various sources. The tables provided an easy way of capturing the multiple factors and the resulting decisions. Trees could not be used because all the rules and questions had to be applied to all the cases. i.e. The questions did not depend on the answers to the questions asked before them.

## **3 Intermediate Knowledge Representation**

As mentioned in the previous section, the elicited domain knowledge was modeled using decision tables. The number of factors considered by the system were narrowed down two factors, risk and duration due to the reasons specified in Section 1.1. The following sections present the intermediate knowledge representation used to model the knowledge base for individual factors and the overall investment choice.

### **3.1 Risk Portfolio Assessment**

The risk portfolio of an investor depends on a number of factors like age, time to retirement, dependencies, job security and income. The knowledge base for risk consists of multiple rules for each of the factors. Each rule is given a score. Each factor is presented to the user through a question. The answers to the questions are used to fire the rules and calculate the total score for that investor. If the total score is above 32 the investor is said to have a high risk portfolio. If the total score is between 20 and 32 the investor is said to have a medium risk portfolio and a total score which is below 20 is interpreted to mean that the investor has a low risk portfolio. Tables 1 and 2 present the questions and the decision table for risk assessment.

Table 1: Questions for risk assessment.

Question Name	Question
<b>Age</b>	Please enter your age
<b>Retirement</b>	Please enter the number of years to your retirement
<b>Dependency</b>	Please enter the number of years you expect to have others substantially dependent on your for financial support
<b>Income</b>	Please enter your present annual income
<b>Acceptable Loss</b>	Please enter the percentage of loss you are willing to accept with your investment
<b>Security</b>	How do you see the security of your Job or Business in the next 5 years ? (bleak/satisfactory/excellent)
<b>Knowledge</b>	Are you (very/somewhat/not) knowledgeable about investments, property market and the stock market?
<b>Risk Acceptance</b>	Are you willing to take (significant/some/little) risk for higher possible returns?
<b>Goals</b>	What are the chances of your retirement goals being satisfied by your current income and assets? (high/maybe/low)
<b>Description</b>	Which one of the following describes you best? I am conservative, I worry about money (enter: A) I like things to go according to my plans, I like to be in control (enter: B) I am very comfortable in taking calculated risk with money (enter: C)

### 3.2 Duration Portfolio Assessment

The duration portfolio assessment is performed using only three rules and one question. The question asks the investor for how long they want to invest their money. Up to 2 years is deemed to be short term, 3 to 6 years is deemed to be medium term and anything above 7 years is deemed to be long term.

### 3.3 Investment Direction Advice

Once the risk and duration portfolios have been obtained using their decision tables. An investment advice decision table which uses the risk and duration portfolios to provide advice is used. Table 3 presents that decision table. As explained before only the duration and risk factors are considered.

Table 2: Decision table for risk portfolio assessment.

Question Name	Max-Value	Min-Value	Text-Value	Score
Age	29	na	na	4
Age	39	30	na	3
Age	49	40	na	2
Age	59	50	na	1
Age	na	60	na	0
Retirement	9	na	na	0
Retirement	14	10	na	1
Retirement	19	15	na	2
Retirement	24	20	na	3
Retirement	na	25	na	4
Dependency	0	na	na	4
Dependency	5	1	na	3
Dependency	10	6	na	2
Dependency	15	11	na	1
Dependency	na	16	na	0
Income	34999	na	na	0
Income	44999	35000	na	1
Income	54999	45000	na	2
Income	64999	55000	na	3
Income	na	65000	na	4
Acceptable Loss	5	na	na	0
Acceptable Loss	10	6	na	1
Acceptable Loss	15	11	na	2
Acceptable Loss	20	16	na	3
Acceptable Loss	na	21	na	4
Security	na	na	bleak	0
Security	na	na	satisfactory	2
Security	na	na	excellent	4
Knowledge	na	na	very	4
Knowledge	na	na	somewhat	2
Knowledge	na	na	not	0
Risk Acceptance	na	na	significant	4
Risk Acceptance	na	na	some	2
Risk Acceptance	na	na	little	0
Goals	na	na	low	4
Goals	na	na	maybe	2
Goals	na	na	high	0
Description	na	na	A	0
Description	na	na	B	2
Description	na	na	C	4

Table 3: Decision table for investment direction advice.

Investment Type	Duration	Returns	Liquidity	Risk
Short Term Deposits	Short	Low	High	Low
Long Term Deposits	Short or Medium	Low to Medium	Medium	Low
Bonds	Medium or Long	Medium	Medium	Low to Medium
Property Market	Long	High	Low	Medium to High
Shares	Long	High	Medium	High

## 4 Knowledge Representation Using Rules

The rules used by the system flow naturally from the decision tables. Each row in the decision tables forms a rule. Therefore they will not be listed here for brevity's sake.

## 5 Knowledge Representation using CLIPS Rules

The CLIPS representation of the rules shown in the decision tables is included in Appendix A.

## 6 Test Problems

The test problems are presented in the following subsections. The problems represent three fictional investors. The problems are described by providing the answers for the questions asked by the system and also providing the expected advice.

### 6.1 Test Problem 1 - Young Daredevil

Age 25

Retirement 35

Dependency 0

Income 45000

Acceptable Loss 20

Security excellent

Knowledge somewhat

Risk Acceptance significant

Goals low

Description C

Duration 8

The system should advise the young daredevil to invest in high risk and long term investments like shares and property.

## **6.2 Test Problem 2 - Middle Aged Hard Worker**

**Age** 45

**Retirement** 15

**Dependency** 10

**Income** 66000

**Acceptable Loss** 10

**Security** excellent

**Knowledge** somewhat

**Risk Acceptance** some

**Goals** maybe

**Description** B

**Duration** 4

The system should advise the middle aged hard worker to invest mostly in medium risk and medium term investments like bonds and fixed term deposits and if comfortable invest small amounts in shares or the property market.

## **6.3 Test Problem 3 - Retired Businessman**

**Age** 60

**Retirement** 0

**Dependency** 0

**Income** 50000

**Acceptable Loss** 5

**Security** bleak

**Knowledge** not

**Risk Acceptance** little

**Goals** low

**Description** A

**Duration** 2

The system should provide the advice of investing in short term and low risk investments like bank deposits.

## 7 Usage Instructions

1. Load Investment.CLP in the CLIPS interpreter.
2. Reset the CLIPS interpreter.
3. Run the CLIPS interpreter.
4. Answer the questions. Be careful and make sure that the answers are spelled and typed(case-sensitive) exactly like the options shown.

## 8 Limitations and Regrets

As explained before, in order to reduce the number of rules, the system's capability was reduced to only providing advice about an investment direction rather than specific investment advice. The number of factors considered were also reduced to only risk and duration.

I regret not having developed a graphical user interface for the system. But it was not possible due to time constraints and high work load in other papers.

## References

- [1] U. Loerch, "Knowledge Engineering - Compsci 367 - Lecture 2," Lecture Slides - University of Auckland, 2004.
- [2] K. M. Morris and A. H. Siegel, *Wall Street Journal Guide to Understanding Money and Investing*, paperback ed. Fireside, August 1999.
- [3] New Zealand Government, "Sorted: Financial Planning Advice," <http://www.sorted.org.nz/>, October 2004, [Online].

## A CLIPS Rules

```
;;;;;;;;;
;;
;; RULES FOR CALCULATING THE RISK SCORE
;;
;;;;;;;;;

(scoreRule (question age) (maxValue 29) (score 4))
(scoreRule (question age) (maxValue 39) (minValue 30) (score 3))
(scoreRule (question age) (maxValue 49) (minValue 40) (score 2))
(scoreRule (question age) (maxValue 59) (minValue 50) (score 1))
(scoreRule (question age) (minValue 60) (score 0))

(scoreRule (question retirement) (maxValue 9) (score 0))
```

```

(scoreRule (question retirement) (maxValue 14) (minValue 10) (score 1))
(scoreRule (question retirement) (maxValue 19) (minValue 15) (score 2))
(scoreRule (question retirement) (maxValue 24) (minValue 20) (score 3))
(scoreRule (question retirement) (minValue 25) (score 4))

(scoreRule (question dependency) (maxValue 0) (score 4))
(scoreRule (question dependency) (maxValue 5) (minValue 1) (score 3))
(scoreRule (question dependency) (maxValue 10) (minValue 6) (score 2))
(scoreRule (question dependency) (maxValue 15) (minValue 11) (score 1))
(scoreRule (question dependency) (minValue 16) (score 0))

(scoreRule (question income) (maxValue 34999) (score 0))
(scoreRule (question income) (maxValue 44999) (minValue 35000) (score 1))
(scoreRule (question income) (maxValue 54999) (minValue 45000) (score 2))
(scoreRule (question income) (maxValue 64999) (minValue 55000) (score 3))
(scoreRule (question income) (minValue 65000) (score 4))

(scoreRule (question acceptableLoss) (maxValue 5) (score 0))
(scoreRule (question acceptableLoss) (maxValue 10) (minValue 6) (score 1))
(scoreRule (question acceptableLoss) (maxValue 15) (minValue 11) (score 2))
(scoreRule (question acceptableLoss) (maxValue 20) (minValue 16) (score 3))
(scoreRule (question acceptableLoss) (minValue 21) (score 4))

(scoreRule (question security) (textValue bleak) (score 0))
(scoreRule (question security) (textValue satisfactory) (score 2))
(scoreRule (question security) (textValue excellent) (score 4))

(scoreRule (question knowledge) (textValue very) (score 4))
(scoreRule (question knowledge) (textValue somewhat) (score 2))
(scoreRule (question knowledge) (textValue not) (score 0))

(scoreRule (question riskAcceptance) (textValue significant) (score 4))
(scoreRule (question riskAcceptance) (textValue some) (score 2))
(scoreRule (question riskAcceptance) (textValue little) (score 0))

(scoreRule (question goals) (textValue low) (score 4))
(scoreRule (question goals) (textValue maybe) (score 2))
(scoreRule (question goals) (textValue high) (score 0))

(scoreRule (question description) (textValue A) (score 0))
(scoreRule (question description) (textValue B) (score 2))
(scoreRule (question description) (textValue C) (score 4))

;;;;;;;
;;
;; RULES FOR DERIVING THE RISK PORTFOLIO FROM THE TOTAL RISK SCORE
;;
;;;;;;;

```

```
(defrule assertRiskPortfolioHigh
?systemStateFact <- (systemState (state riskQuestionsComplete))
?scoreFact <- (score (type risk) (points ?points))
(test (> ?points 32))
=>
(retract ?systemStateFact ?scoreFact)
(assert (riskPortfolio high))
(assert (systemState (state riskAssesmentComplete))))

(defrule assertRiskPortfolioMedium
?systemStateFact <- (systemState (state riskQuestionsComplete))
?scoreFact <- (score (type risk) (points ?points))
(test (>= ?points 20))
(test (<= ?points 31))
=>
(retract ?systemStateFact ?scoreFact)
(assert (riskPortfolio medium))
(assert (systemState (state riskAssesmentComplete))))

(defrule assertRiskPortfolioLow
?systemStateFact <- (systemState (state riskQuestionsComplete))
?scoreFact <- (score (type risk) (points ?points))
(test (>= ?points 0))
(test (<= ?points 19))
=>
(retract ?systemStateFact ?scoreFact)
(assert (riskPortfolio low))
(assert (systemState (state riskAssesmentComplete))))

;;;;;;;;;
;;
;; RULES FOR DERIVING THE DURATION PORTFOLIO
;;
;;;;;;;;;

(scoreRule (question duration) (maxValue 2) (portfolio short))
(scoreRule (question duration) (minValue 3)(maxValue 6) (portfolio medium))
(scoreRule (question duration) (minValue 7) (portfolio long))

;;;;;;;;;
;;
;; RULES FOR PROVIDING INVESTMENT ADVISE BASED ON RISK AND DURATION
;;
;;;;;;;;;

(defrule printoutAdvice1
"Short Term"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?durationPortfolio <- (durationPortfolio short)
```

```
?riskPortfolio <- (riskPortfolio high|medium)
=>
(retract ?systemStateFact ?durationPortfolio ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments which are short term and have medium
to high risk." crlf
"Invest majority of your funds in Short Term or Fixed Term Bank Deposits." crlf
"They are both very low risk and low returns investments." crlf
"If you feel adventurous you can invest a small percentage of your funds
in Stocks." crlf
"Always try to diversify your investments." crlf
"Talk with an investment advisor if you feel uncomfortable about this
advice." crlf
"Goto www.sorted.co.nz for more detailed information about Bank Deposits." crlf))

(defrule printoutAdvice2
"Short Term"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?durationPortfolio <- (durationPortfolio short)
?riskPortfolio <- (riskPortfolio low)
=>
(retract ?systemStateFact ?durationPortfolio ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments which are short term and have low risk." crlf
"Invest majority of your funds in Short Term or Fixed Term Bank Deposits." crlf
"They are both very low risk and low returns investments." crlf
"Always try to diversify your investments." crlf
"Talk with an investment advisor if you feel uncomfortable about this
advice." crlf
"Goto www.sorted.co.nz for more detailed information about Bank Deposits." crlf))

(defrule printoutAdvice3
"Medium Term"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?durationPortfolio <- (durationPortfolio medium)
?riskPortfolio <- (riskPortfolio high|medium)
=>
(retract ?systemStateFact ?durationPortfolio ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments which are medium term and have medium
to high risk." crlf
"Invest majority of your funds in Fixed Term Bank Deposits or Bonds." crlf
"They are both very low risk and medium returns investments." crlf
"If you feel adventurous you can invest a small percentage of your funds
in Stocks or the Property market." crlf
"Always try to diversify your investments." crlf
"Talk with an investment advisor if you feel uncomfortable about this
advice." crlf
"Goto www.sorted.co.nz for more detailed information about Bank Deposits
```

```
and Bonds." crlf))
```

```
(defrule printoutAdvice4
"Medium Term"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?durationPortfolio <- (durationPortfolio medium)
?riskPortfolio <- (riskPortfolio low)
=>
(retract ?systemStateFact ?durationPortfolio ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments which are medium term and have
low risk." crlf
"Invest majority of your funds in Fixed Term Bank Deposits or Bonds." crlf
"They are both very low risk and medium returns investments." crlf
"Always try to diversify your investments." crlf
"Talk with an investment advisor if you feel uncomfortable about this
advice." crlf
"Goto www.sorted.co.nz for more detailed information about Bank Deposits
and Bonds." crlf))
```

```
(defrule printoutAdvice5
"Long Term - Medium Risk"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?durationPortfolio <- (durationPortfolio long)
?riskPortfolio <- (riskPortfolio medium)
=>
(retract ?systemStateFact ?durationPortfolio ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments with medium risk and which are
long term." crlf
"Invest most of your funds in the Property Market. Invest some of your
funds in shares." crlf
"They are both very high returns investments." crlf
"Always try to diversify your investments." crlf
"Talk with an investment advisor if you feel uncomfortable about
this advice." crlf
"Goto www.sorted.co.nz for more detailed information about the
Property Market or Shares." crlf))
```

```
(defrule printoutAdvice6
"Long Term - High Risk"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?durationPortfolio <- (durationPortfolio long)
?riskPortfolio <- (riskPortfolio high)
=>
(retract ?systemStateFact ?durationPortfolio ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments with high risk and which are
long term." crlf
```

```
"Invest most of your funds in Shares. Invest some of your funds in the
Property Market." crlf
"They are both very high returns investments." crlf
"Always try to diversify your investments." crlf
"Talk with an investment advisor if you feel uncomfortable about
this advice." crlf
"Goto www.sorted.co.nz for more detailed information about the Shares or
the Property Market." crlf))
```

```
(defrule printoutAdvice7
"Low Risk"
?systemStateFact <- (systemState (state durationAssesmentcomplete))
?riskPortfolio <- (riskPortfolio low)
=>
(retract ?systemStateFact ?riskPortfolio)
(assert (systemState) (state complete))
(printout t "You require investments with low risk and which are
long term." crlf
"Invest your funds in Bank Deposits." crlf
"It is a very low returns investment but has almost no risk." crlf
"You can invest a small amount in Bonds but they involve a little
more risk."
"Diversify your investments by using deposits of varying terms with
a greater ratio
of long term deposits." crlf
"Talk with an investment advisor if you feel uncomfortable about this
advice." crlf
"Goto www.sorted.co.nz for more detailed information about the Shares
or the Property Market." crlf))
```