THE MATHEMATICAL ASSOCIATION OF VICTORIA

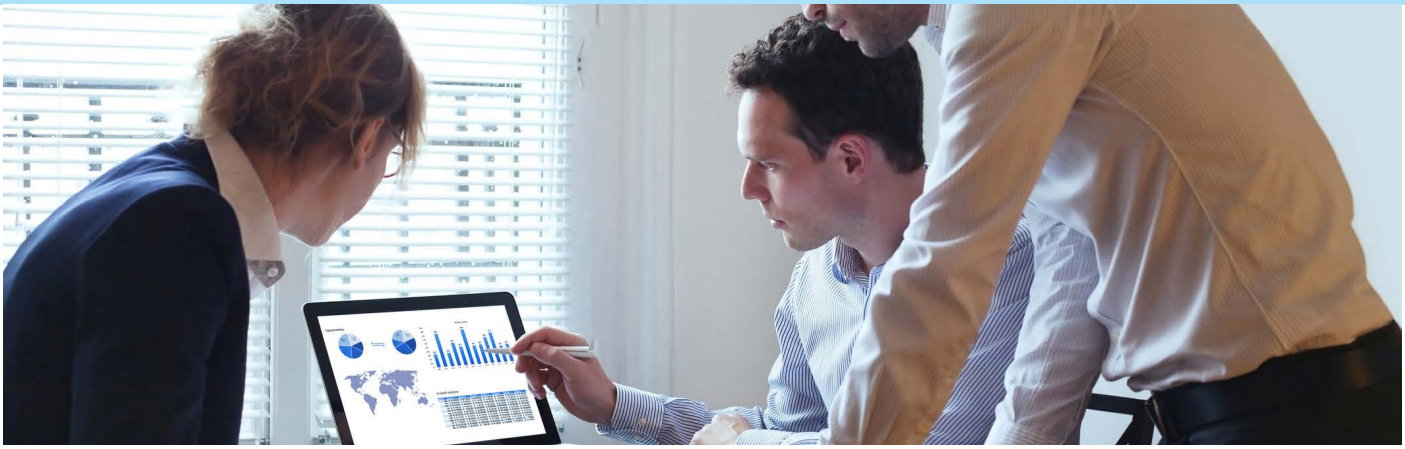
RESERVE BANK OF AUSTRALIA

TEACHER NOTES

MATHEMATICS IN CAREERS

Investigation - Exploring changes in the cash rate and its effect on the economy

Key career focus for this investigation: Economics, commerce
Related career areas: Finance, statistics and data science



THINKING ABOUT CAREERS

- Brainstorm the tasks done in the economics and commerce professions, and think where maths is frequently used. The Explore Economics pages at: rba.gov.au/education/explore-economics can be used to discover more about what economists do and the broad range of fields and careers economics can lead to. Think about: *How is maths used in these scenarios? What maths is used in these scenarios?*
- This task focuses on how maths is used in economics and commerce through investigating changes in the cash rate and its effect on the economy.
- The task specifically looks at supply and demand.
- For a more extensive list of careers related to this task, with a maths / science focus, refer to the table at the end of the task and explore the maths used in these jobs.

MATHEMATICS IN EVERYDAY LIFE AND CAREERS

Mathematical focus for this investigation

- Representing word problems with simple linear equations and solving them to answer questions
- Solving simple equations arising from formulas
- Re-arranging expressions to make a specified variable the subject
- Associating the solution of simultaneous equations with the coordinates of the intersection of their corresponding graphs.

Linear equations use one or more variables where one variable is dependent on the other. Many people use linear equations every day, even if they do the calculations in their head or just draw a line graph.

Almost any situation where there is an unknown quantity can be represented by a linear equation, like figuring out income over time, calculating mileage rates, or predicting profit. Brainstorm and share scenarios where this mathematics may be used in commerce and economics to solve problems. For reference, see rba.gov.au/education/explore_economics

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TEACHER INFORMATION

LINKS TO VICTORIAN CURRICULUM

Mathematics links to Victorian Curriculum Level 10	Application to work and life
Linear and non-linear relationships Solve problems involving linear equations, including those derived from formulas (VCMNA335) Solve simultaneous linear equations, using algebraic and graphical techniques including using digital technology (VCMNA337) Solve problems involving parallel and perpendicular lines (VCMNA338) Solve linear equations involving simple algebraic fractions (VCMNA340) **Patterns and algebra** Substitute values into formulas to determine an unknown and re-arrange formulas to solve for a particular term (VCMNA333) Apply the four operations to simple algebraic fractions with numerical denominators (VCMNA331)	The skill of modelling relationships, comparing different scenarios, is used in many workplaces. The relationship may be linear or other. Economists graph data and compare the graphs, changing one variable to see the effect on the other to test hypotheses. Linear equations use one or more variables where one variable is dependent on the other. Many situations where there is an unknown quantity can be represented by a linear equation, such as working out income over time, calculating mileage rates, or predicting profit. Many people use linear equations every day, even if they do the calculations in their head without drawing a line graph.
Mathematics links to Victorian Curriculum Level 10A	**Application to work and life**
Use function notation to describe the relationship between dependent and independent variables in modelling contexts (VCMNA363) Solve simultaneous equations using systematic guess-check-and-refine with digital technology (VCMNA364)	Another important aspect of understanding graphs that is used in workplaces is the interpretation of graphs. In this example, an economist needs to be able to model the data by identifying independent and dependent variables and represent the relation between them using tables, graphs and rules. Also, to identify and interpret the point of intersection of the two graphs.
Further example of other maths used: • Interpreting graphs • Calculating percentages	An important aspect of working with financial mathematics is being able to interpret graphs and discuss what trends may be evident from the data. Working with percentages such as calculating interest rates, calculating percentage increase/decrease and calculating profits/losses as percentages is also a key mathematical skill required.

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PROFICIENCY FOCUS: VICTORIAN CURRICULUM

This investigation focuses on: Fluency, Understanding, Problem Solving

Fluency describes students developing skills in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily.

This investigation focuses on:

- Solving simple equations arising from formulas.
- Re-arranging expressions to make a specified variable the subject.
- Solving problems using the fact that the product of the gradients of perpendicular lines is –1 and conversely that if the product of the gradients of two lines is –1 then they are perpendicular.
- Solving linear equations, including those involving one or two simple algebraic fractions, and checking solutions by substitution.
- Representing word problems, including those involving fractions, as equations and solving them to answer the question.

Understanding refers to students building a robust knowledge of adaptable and transferable mathematical concepts and structures.

This investigation focuses on:

- Representing word problems with simple linear equations and solving them to answer questions and hence the student's ability to describe their thinking mathematically.
- Connecting related ideas through associating the solution of simultaneous equations with the coordinates of the intersection of their corresponding graphs.
- Interpret mathematical information.

Problem Solving is the ability of students to make choices, interpret, formulate, model and investigate situation, select and use technological functions and communicate solutions effectively.

This investigation focuses on:

- Students applying their existing strategies to seek solutions.

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STUDENT INVESTIGATION WITH TEACHER GUIDE

INVESTIGATION BACKGROUND

It is the responsibility of the Reserve Bank of Australia (RBA) to set interest rates in a way that best contributes to price stability, full employment, and the economic prosperity and welfare of the people of Australia.

To achieve price stability, the RBA's inflation target is to keep consumer price inflation between 2–3%, on average, over time. This target is flexible and allows for temporary fluctuations in inflation above or below the target. To achieve this goal, the RBA sets the cash rate to influence economic activity and inflation. A reduction in the cash rate typically stimulates spending and inflation and an increase in the cash rate typically dampens spending and inflation.

YOUR INVESTIGATION

It is the year 2025 and you are an economist at the RBA. The role of your team is to analyse how changes in the economy (in particular changes to the aggregate demand and supply of goods and services) can lead to inflation being pushed away from the inflation target. If inflation is pushed away from its inflation target the RBA can change the cash rate to influence economic activity and inflation.

Together with your team, **you have been asked to look at possible changes in aggregate demand and supply and to advise your manager what effect these changes have on inflation under different scenarios.**

Furthermore, the next meeting of the Reserve Bank Board is coming up. In this meeting, the Board will decide on the appropriate level of the cash rate to meet the inflation target. **You have also been asked to offer recommendations to the Board on how to set the cash rate in the scenarios you considered.**

A model for aggregate demand and supply

To study the effect a change in aggregate demand or supply has on inflation and how monetary policy should respond you will use a mathematical model. Using a model will help your team think about how changes in the demand for goods and services by households (consumption) or firms (investment) interact with what can be produced in the economy to influence inflation. The model will also help you think through, and assess, how the cash rate influences the economy.

For your analysis, your department has developed a set of algebraic expressions for you to use. This model describes the quantity of goods and services demanded (aggregate demand) and produced (aggregate supply) in the Australian economy as the intersection between two functions:

- **Supply of all goods and services Q_S:** the quantity of goods and services that firms produce, which is increasing in the average price p; and
- **Demand for all goods and services Q_D:** the quantity of goods and services that households want to purchase, which is decreasing in p.

(Think about why the quantity of goods and services households want to purchase increases as prices decrease.)

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We will assume that these two functions are:
$Q_S = a_S + b_S \times p$ and
$Q_D = a_D - b_D \times p$

where a_S, b_S, a_D and b_D are (the intercept and slope) parameters satisfying

$a_D > a_S > 0$, $b_S > 0$ and

$b_D > 0$ (these parameters should be thought of as fixed values).

Prices can be expected to move to the level that makes supply equal demand, i.e. $Q_S = Q_D$. (Think about why.) We say that when supply equals demand, the economy is in *equilibrium*. Denote the equilibrium price level as p^* and the equilibrium quantity supplied and demanded as Q^*.

The RBA can influence aggregate demand by changing the cash rate. One way to illustrate this in our model is to assume that a decline in the cash rate affects the intercept of the demand function a_D. Your team have looked at the data around the last times when the cash rate has been changed and have observed that the relationship between a_D and the cash rate cr can be approximated by the following function:

$$a_D = 12.5 - \frac{1}{3} \times cr.$$

YOUR TASKS

Your manager would like to know how equilibrium prices and equilibrium demand and supply depend on the parameters of the model.

PART 1

Express p^* and Q^* as functions of only the parameters a_S, a_D, b_S and b_D.

Supply $Q_S = a_S + b_S \times p$ *Blue denotes price*
Demand $Q_D = a_D - b_D \times p$
At equilibrium, supply = demand $Q_S = Q_D$
equilibrium price p^*

At equilibrium:

$$a_S + b_S \times p^* = a_D - b_D \times p^*$$
$$a_S - a_D = -b_S \times p - b_D \times p^*$$
$$a_S - a_D = p^*(-b_S - b_D)$$
$$p^* = \frac{a_S - a_D}{-b_S - b_D}$$
$$p^* = \frac{a_S - a_D}{-(b_S + b_D)}$$

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$$Q^* = a_S + b_S \times \left(\frac{a_S - a_D}{-(b_S + b_D)} \right)$$

$$Q^* = a_S + \frac{b_S(a_S - a_D)}{-(b_S + b_D)}$$

$$Q^* = a_S - \frac{b_S(a_S - a_D)}{(b_S + b_D)}$$

PART 2

Plot Q_S and Q_D on a graph that has p on the x-axis and Q_S and Q_D on the y-axis (the slopes and intercepts do not need to be to scale). Identify p^* and Q^* on the graph.

$Q_S = a_S + b_S \times p$

$Q_S = p \times b_S + a_S$ *p denotes gradient, a_S denotes y-intercept*

$Q_D = a_D - b_D \times p$

$Q_D = -p \times b_D + a_D$ *-p denotes gradient, a_D denotes y-intercept*

PART 3

Assume that $a_S = 2$, and $b_S = 0.6$ and $b_D = 0.4$. The cash rate is currently set to 1.5% (so $cr = 1.5$). What is the equilibrium price level p^* and the equilibrium quantity produced and demanded Q^*?

$a_S = 2$, $b_S = 0.6$ and $b_D = 0.4$ $cr = 1.5$

$$a_D = 12.5 - \frac{1}{3} \times 1.5$$

$$a_D = 12.5 - \frac{1.5}{3}$$

$$a_D = 12.5 - 0.5$$

$$a_D = 12$$

$$p^* = \frac{2 - 12}{-(0.6 + 0.4)}$$

$$p^* = \frac{-10}{-1}$$

$$p^* = 10$$

$$Q^* = 2 - \frac{0.6(2 - 12)}{(0.6 + 0.4)}$$

$$Q^* = 2 - \frac{0.6(-10)}{1}$$

$$Q^* = 2 - \frac{-6}{1}$$

$$Q^* = 8$$

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PART 4
Your manager would now like to understand what effect a decrease in the cash rate would have on supply and demand, and on prices.

How could a decrease in the cash rate affect the supply or demand functions in the graph? In which direction do Q^* and p^* move in general if the cash rate decreases?

PART 5
Your manager would now like to know what the effects on prices and the quantity demanded and supplied would be if the cash rate were to be reduced by 1 percentage point to 0.5%.

In this case what are the new Q^* and p^*? What is the inflation rate between the new price level p_1^* and the old price level $p_0^* = 10$?

PART 6
Now assume that the cash rate is still at $cr = 1.5$, but there is a change to the production side of the economy, so that a_S changes to $a_S = 2.25$.

Show in your graph what happens to Q^* and p^* in this case. What are the new values for Q^* and p^*? If the RBA wants the price level to be stable (no inflation), how should it set the cash rate? [Hint: The RBA can still influence demand by changing the parameter a_D. At what cash rate is inflation equal to zero?]

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REFERENCE MATERIAL

- Modules for Years 9 and 10: The Nature of the Economy
- Modules for Years 9 and 10: Reading and Interpreting Charts
- Explainer: Australia's Inflation Target
- Explainer: The Transmission of Monetary Policy
- Explainer: Inflation and its Measurement
- Explore Economics

ENABLING PROMPTS

For task 1 and 2:
What type of functions are
$Q_S = a_S + b_S \times p$ and $Q_D = a_D - b_D \times p$

What is the general equation of a function of this type?

What algebraic term in this general equation normally denotes
- the gradient (slope)
- the y–intercept

Use this prior knowledge to now identify the gradient and y–intercept of Q_S and Q_D.

ADDITIONAL INFORMATION

The cash rate is the market interest rate at which banks can borrow from each other, and it has a strong influence over other interest rates, such as deposit and lending rates for households and businesses.

Lower interest rates increase aggregate demand for goods and services in many ways. For example, lower lending rates can encourage households to increase their borrowing as they face lower repayments on their credit cards and mortgages and because banks will generally lend more to them. Because of this, lower lending rates support higher consumption of goods and services and increase demand for housing.

But it can take a while for firms to increase supply because more workers, equipment and infrastructure may be required for the production of goods and services. Because of this, aggregate demand is initially greater than aggregate supply, putting upward pressure on prices. As businesses increase their prices more rapidly in response to higher demand, this leads to higher inflation. (Higher interest rates have the opposite effect on demand and supply.)

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CAREERS RELATED TO THIS INVESTIGATION

Refer to the student investigation, it provides:
- An extensive table of careers related to this investigation
- Further career references

CAREERS ACTIVITIES

Refer to the student investigation, it provides:
- A table of the top 10 rated jobs of 2021. This data comes from careercast.com.
- Tables and graphs from the RBA (containing Australian data)

Have students investigate the jobs specific to this investigation using either or both sources.
(Note: the RBA recommended resources refer more specifically to economics).

INDUSTRY PARTNER

This project was produced collaboratively between The Mathematical Association of Victoria (MAV) and the Reserve Bank of Australia (RBA).

The Reserve Bank has the following roles and functions:

Monetary policy
The Reserve Bank conducts monetary policy to achieve its goals of price stability, full employment and the economic prosperity and welfare of the Australian people.

Operations in financial markets
The Reserve Bank operates in domestic and international financial markets. This is to implement monetary policy, help ensure the smooth functioning of payments and manage Australia's foreign exchange reserves.

Financial stability
The Reserve Bank is responsible for overall financial system stability. It does this by managing and providing liquidity to financial institutions, monitoring risks and cooperating with other organisations as part of the Council of Financial Regulators.

Payments and financial markets infrastructure
The Reserve Bank has responsibility for ensuring the stability, efficiency and competitiveness of the payments system. It also has a regulatory and operational role in ensuring that the payments infrastructure promotes financial stability.

Banknotes
The Reserve Bank is responsible for producing and issuing Australia's banknotes. Its goal is to produce banknotes that everyone can trust, both as a means of payment and a store of value.

Banking services
The Reserve Bank provides a range of banking services to the Australian Government and overseas central banks. Payments and transactions often relate to the everyday lives of Australians, such as social security benefits and emergency payments to people affected by natural disasters.

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