

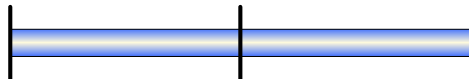
GOVERNMENT AND FISCAL POLICY IN THE CONSUMPTION-SAVINGS MODEL (CONTINUED)

FEBRUARY 23, 2009

A Government in the Two-Period Model

A DYNAMIC MODEL OF THE GOVERNMENT

- So far only consumers in our two-period world
- Introduce government in very simple form
 - Exists for both periods
 - Has spending in each period it needs to finance – can be financed via
 - Taxes
 - Issuing government debt/assets



- **Notation**
 - g_1 : real government spending in period 1
 - g_2 : real government spending in period 2
 - b_0 : government asset position at beginning of period 1/end of period 0
 - b_1 : government asset position at beginning of period 2/end of period 1
 - b_2 : government asset position at beginning of period 3/end of period 2
 - r : real interest rate between periods

February 23, 2009

2

GOVERNMENT BUDGET CONSTRAINT(S)

- Adopt a **lifetime** view of the budget constraint(s)
 - All analysis conducted from perspective of beginning of period 1
 - Period-1 government budget constraint $g_1 + b_1 = t_1 + (1+r)b_0$
 - Period-2 government budget constraint $g_2 + b_2 = t_2 + (1+r)b_1$

Asset position at end of period 1/beginning of period 2 the key link

Assume = 0 (fully-rational, informed, benevolent government)

- Combine into **lifetime budget constraint (LBC)**
 - Solve period-2 budget constraint for b_1 ...
 - ...and substitute into period-1 budget constraint

$$g_1 + \frac{g_2}{1+r} = t_1 + \frac{t_2}{1+r} + (1+r)b_0$$

Present discounted value (PDV) of all lifetime government expenditure Present discounted value (PDV) of all lifetime government income

IMPORTANT: Government must balance its budget over its *lifetime*, not necessarily in each period

For graphical simplicity, will often assume $b_0 = 0$ (i.e., government begins life with zero net wealth).
 Note this is a *different* assumption than $b_2 = 0$.

CONSUMER BUDGET CONSTRAINT(S)

- Introduce tax payments into consumer side of model
 - All in real terms for simplicity – can cast in nominal terms by multiplying by P
 - Period-1 budget constraint $c_1 + t_1 + a_1 - a_0 = y_1 + ra_0$
 - Period-2 budget constraint $c_2 + t_2 + a_2 - a_1 = y_2 + ra_1$
- Combine into **lifetime budget constraint (LBC)**
 - Solve period-2 budget constraint for a_1 ...
 - ...and substitute into period-1 budget constraint

$$c_1 + \frac{c_2}{1+r} = y_1 - t_1 + \frac{y_2 - t_2}{1+r} + (1+r)a_0$$

Present discounted value (PDV) of all lifetime expenditure Present discounted value (PDV) of all lifetime **disposable** income (i.e., after-tax income)

ECONOMY-WIDE RESOURCE FRONTIER

- Consumer lifetime budget constraint

$$c_1 + \frac{c_2}{1+r} = y_1 - t_1 + \frac{y_2 - t_2}{1+r} + (1+r)a_0$$

- Government lifetime budget constraint

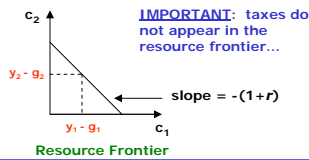
$$g_1 + \frac{g_2}{1+r} = t_1 + \frac{t_2}{1+r} + (1+r)b_0$$

- Summing the two yields **economy-wide resource frontier**

$$c_1 + \frac{c_2}{1+r} = y_1 - g_1 + \frac{y_2 - g_2}{1+r} + (1+r)(a_0 + b_0)$$

Suppose = 0 for graphical simplicity

- aka "production possibilities frontier" (PPF)
- The GDP accounting equation in two-period form



IMPORTANT: taxes do not appear in the resource frontier...

THEOREM (intermediate micro): If taxes are *lump-sum*, then consumer optimal choices can be obtained by analyzing *either* the consumer LBC *or* the economy-wide resource frontier (superimpose indifference map), and either approach will yield the same predictions.

An important theoretical result for the analysis of tax policy.

NATIONAL SAVINGS

- National savings = savings by consumers + savings by government + savings by firms

- No firms in our model (yet..), so $s_1^{firm} = 0$

- $s_1^{priv} = y_1 - t_1 - c_1$

- $s_1^{govt} = t_1 - g_1$

NATIONAL SAVINGS

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - t_1 - c_1 + t_1 - g_1$

NATIONAL SAVINGS

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - \cancel{t_1} - c_1 + \cancel{t_1} - g_1 = y_1 - c_1 - g_1$

EFFECTS OF TAX POLICY

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - \cancel{t_1} - c_1 + \cancel{t_1} - g_1 = y_1 - c_1 - g_1$
- Policy Experiment: Is national savings affected by a decrease in t_1 ?
 - Suppose g_1 and g_2 do not change
 - Question 1: Effect on t_2 ?
 - t_2 must rise (examine government lifetime budget constraint)

EFFECTS OF TAX POLICY

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - \cancel{t_1} - c_1 + \cancel{t_1} - g_1 = y_1 - c_1 - g_1$
- Policy Experiment: Is national savings affected by a decrease in t_1 ?
 - Suppose g_1 and g_2 do not change
 - Question 1: Effect on t_2 ?
 - t_2 must rise (examine government lifetime budget constraint)
 - Question 2: Effect of tax changes on consumers' optimal choice of period-1 consumption?

EFFECTS OF TAX POLICY

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - \cancel{t_1} - c_1 + \cancel{t_1} - g_1 = y_1 - c_1 - g_1$

- Policy Experiment: Is national savings affected by a decrease in t_1 ?
 - Suppose g_1 and g_2 do not change
 - Question 1: Effect on t_2 ?
 - t_2 must rise (examine government lifetime budget constraint)
 - Question 2: Effect of tax changes on consumers' optimal choice of period-1 consumption?
 - Using intermediate micro theorem, NO EFFECT ON optimal c_1
 - Taxes are lump sum (will define/discuss next time...)
 - Economy-wide resource constraint does not depend on taxes → optimal choice of c_1 unaffected by the change in tax policy

EFFECTS OF TAX POLICY

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - \cancel{t_1} - c_1 + \cancel{t_1} - g_1 = y_1 - c_1 - g_1$

- Policy Experiment: Is national savings affected by a decrease in t_1 ?
 - Suppose g_1 and g_2 do not change
 - Question 1: Effect on t_2 ?
 - t_2 must rise (examine government lifetime budget constraint)
 - Question 2: Effect of tax changes on consumers' optimal choice of period-1 consumption?
 - Using intermediate micro theorem, NO EFFECT ON optimal c_1
 - Taxes are lump sum (will define/discuss next time...)
 - Economy-wide resource constraint does not depend on taxes → optimal choice of c_1 unaffected by the change in tax policy
 - Question 3: Effect of tax changes on period-1 national savings?
 - NONE – because neither g_1 nor c_1 changed

EFFECTS OF TAX POLICY

- National savings = savings by consumers + savings by government + savings by firms
 - No firms in our model (yet.), so $s_1^{firm} = 0$
 - $s_1^{priv} = y_1 - t_1 - c_1$
 - $s_1^{govt} = t_1 - g_1$
 - $s_1^{nat} = s_1^{priv} + s_1^{govt} = y_1 - t_1 - c_1 + t_1 - g_1 = y_1 - c_1 - g_1$
- Analyzing effects of changes in tax policy on optimal consumption choices is the key
- Policy Experiment: Is national savings affected by a decrease in t_1 ?
 - Suppose g_1 and g_2 do not change
 - Question 1: Effect on t_2 ?
 - t_2 must rise (examine government lifetime budget constraint)
 - Question 2: Effect of tax changes on consumers' optimal choice of period-1 consumption?
 - Using intermediate micro theorem, NO EFFECT ON optimal c_1
 - Taxes are lump sum (will define/discuss next time...)
 - Economy-wide resource constraint does not depend on taxes → optimal choice of c_1 unaffected by the change in tax policy
 - Question 3: Effect of tax changes on period-1 national savings?
 - NONE – because neither g_1 nor c_1 changed

RICARDIAN EQUIVALENCE

- **Ricardian Equivalence Theorem:** For a given time-path of government spending, neither consumption nor national savings is affected by the precise timing of lump-sum taxes
- A benchmark result/concept in the theory of macroeconomic policy

RICARDIAN EQUIVALENCE

- ❑ **Ricardian Equivalence Theorem:** For a given time-path of government spending, neither consumption nor national savings is affected by the precise timing of lump-sum taxes
- ❑ A benchmark result/concept in the theory of macroeconomic policy
- ❑ **Intuition:** Rational consumers understand that a tax cut today means a tax increase in the future (because total government liabilities are unchanged)
 - ❑ Thus entire tax cut is saved by consumers in order to pay higher taxes in the future
 - ❑ Private savings and government savings move in exactly offsetting ways

RICARDIAN EQUIVALENCE

- ❑ **Ricardian Equivalence Theorem:** For a given time-path of government spending, neither consumption nor national savings is affected by the precise timing of lump-sum taxes
- ❑ A benchmark result/concept in the theory of macroeconomic policy
- ❑ **Intuition:** Rational consumers understand that a tax cut today means a tax increase in the future (because total government liabilities are unchanged)
 - ❑ Thus entire tax cut is saved by consumers in order to pay higher taxes in the future
 - ❑ Private savings and government savings move in exactly offsetting ways
- ❑ Ricardian Equivalence is to tax theory what perfect competition is to standard economic theory
 - ❑ Idea relies crucially on lump-sum taxes...
 - ❑ ...even though in reality lump-sum taxes do not exist...

NATURE OF TAXATION

- ❑ **Lump-Sum Tax**
 - ❑ A tax whose total incidence (i.e., total amount paid) does not depend in any way on any economic decisions/choices an individual makes
 - ❑ Real-world examples:

NATURE OF TAXATION

- ❑ **Lump-Sum Tax**
 - ❑ A tax whose total incidence (i.e., total amount paid) does not depend in any way on any economic decisions/choices an individual makes
 - ❑ Real-world examples: ?...

NATURE OF TAXATION

- ❑ **Lump-Sum Tax**
 - ❑ A tax whose total incidence (i.e., total amount paid) does not depend in any way on any economic decisions/choices an individual makes
 - ❑ Real-world examples: ?...

- ❑ Taxes in our two-period framework so far
 - ❑ **Lump-sum!** Total amounts t_1 and t_2 paid by consumer are independent of any of their decisions/choices

$$\text{Period-1 budget constraint} \\ c_1 + t_1 + a_1 - a_0 = y_1 + ra_0$$

$$\text{Period-2 budget constraint} \\ c_2 + t_2 + a_2 - a_1 = y_2 + ra_1$$

NATURE OF TAXATION

- ❑ **Lump-Sum Tax**
 - ❑ A tax whose total incidence (i.e., total amount paid) does not depend in any way on any economic decisions/choices an individual makes
 - ❑ Real-world examples: ?...

- ❑ Taxes in our two-period framework so far
 - ❑ **Lump-sum!** Total amounts t_1 and t_2 paid by consumer are independent of any of their decisions/choices

$$\text{Period-1 budget constraint} \\ c_1 + t_1 + a_1 - a_0 = y_1 + ra_0$$

$$\text{Period-2 budget constraint} \\ c_2 + t_2 + a_2 - a_1 = y_2 + ra_1$$

- ❑ **Proportional (aka distortionary) Tax**
 - ❑ A tax whose total incidence depends on economic decisions/choices an individual makes

NATURE OF TAXATION

- ❑ **Lump-Sum Tax**
 - ❑ A tax whose total incidence (i.e., total amount paid) does not depend in any way on any economic decisions/choices an individual makes
 - ❑ Real-world examples: ?...

- ❑ Taxes in our two-period framework so far
 - ❑ **Lump-sum!** Total amounts t_1 and t_2 paid by consumer are independent of any of their decisions/choices

Period-1 budget constraint

$$c_1 + t_1 + a_1 - a_0 = y_1 + ra_0$$

Period-2 budget constraint

$$c_2 + t_2 + a_2 - a_1 = y_2 + ra_1$$

- ❑ **Proportional (aka distortionary) Tax**
 - ❑ A tax whose total incidence depends on economic decisions/choices an individual makes
 - ❑ In simple two-period framework: consumers only make consumption choices c_1 and c_2

τ is consumption tax rate (aka sales tax rate)

Period-1 budget constraint

$$(1 + \tau_1)c_1 + a_1 - a_0 = y_1 + ra_0$$

Period-2 budget constraint

$$(1 + \tau_2)c_2 + a_2 - a_1 = y_2 + ra_1$$

PROPORTIONAL TAXATION

τ is consumption tax rate (aka sales tax rate)

Period-1 budget constraint

$$(1 + \tau_1)c_1 + a_1 - a_0 = y_1 + ra_0$$

Period-2 budget constraint

$$(1 + \tau_2)c_2 + a_2 - a_1 = y_2 + ra_1$$

- ❑ **Combine into consumer LBC**

$$(1 + \tau_1)c_1 + \frac{(1 + \tau_2)c_2}{1 + r} = y_1 + \frac{y_2}{1 + r} + (1 + r)a_0$$

PROPORTIONAL TAXATION

r is consumption
tax rate (aka sales
tax rate)

Period-1 budget constraint
 $(1 + \tau_1)c_1 + a_1 - a_0 = y_1 + ra_0$

Period-2 budget constraint
 $(1 + \tau_2)c_2 + a_2 - a_1 = y_2 + ra_1$

- **Combine into consumer LBC**

$$(1 + \tau_1)c_1 + \frac{(1 + \tau_2)c_2}{1 + r} = y_1 + \frac{y_2}{1 + r} + (1 + r)a_0$$

- **Slope is** $-\left(\frac{1 + \tau_1}{1 + \tau_2}\right)(1 + r)$
- **Non-lump-sum taxes: optimal consumption choices must be determined using consumer LBC, not economy's resource frontier (i.e., intermediate micro theorem does not apply)**
- **Changes in tax *rates* do affect optimal consumption choices because they *change slope of consumer LBC***

February 23, 2009

23

PROPORTIONAL TAXATION

r is consumption
tax rate (aka sales
tax rate)

Period-1 budget constraint
 $(1 + \tau_1)c_1 + a_1 - a_0 = y_1 + ra_0$

Period-2 budget constraint
 $(1 + \tau_2)c_2 + a_2 - a_1 = y_2 + ra_1$

- **Combine into consumer LBC**

$$(1 + \tau_1)c_1 + \frac{(1 + \tau_2)c_2}{1 + r} = y_1 + \frac{y_2}{1 + r} + (1 + r)a_0$$

- **Slope is** $-\left(\frac{1 + \tau_1}{1 + \tau_2}\right)(1 + r)$
- **Non-lump-sum taxes: optimal consumption choices must be determined using consumer LBC, not economy's resource frontier (i.e., intermediate micro theorem does not apply)**
- **Changes in tax *rates* do affect optimal consumption choices because they *change slope of consumer LBC***
- **Ricardian Equivalence Theorem does not apply**
 - **Changes in tax rates *do* affect national savings**

February 23, 2009

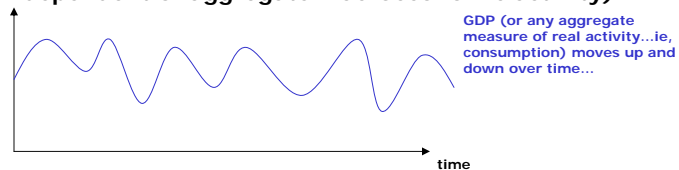
24

RICARDIAN EQUIVALENCE?

- ❑ So why the fascination with Ricardian Equivalence?
- ❑ A benchmark result/concept in the theory of macroeconomic policy
 - ❑ Effects of actual policy proposals can be compared to the Ricardian Equivalence benchmark

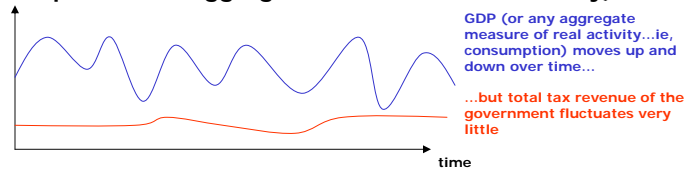
RICARDIAN EQUIVALENCE?

- ❑ So why the fascination with Ricardian Equivalence?
- ❑ A benchmark result/concept in the theory of macroeconomic policy
 - ❑ Effects of actual policy proposals can be compared to the Ricardian Equivalence benchmark
- ❑ At aggregate level, total tax collections sometime "seem" lump-sum (i.e., independent of aggregate macroeconomic activity)



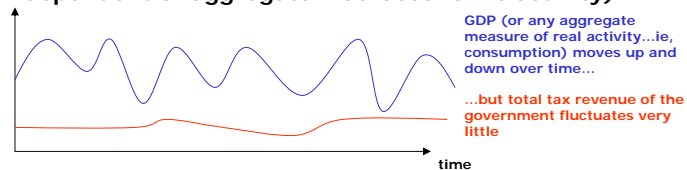
RICARDIAN EQUIVALENCE?

- ❑ So why the fascination with Ricardian Equivalence?
- ❑ A benchmark result/concept in the theory of macroeconomic policy
 - ❑ Effects of actual policy proposals can be compared to the Ricardian Equivalence benchmark
- ❑ At aggregate level, total tax collections sometime “seem” lump-sum (i.e., independent of aggregate macroeconomic activity)



RICARDIAN EQUIVALENCE?

- ❑ So why the fascination with Ricardian Equivalence?
- ❑ A benchmark result/concept in the theory of macroeconomic policy
 - ❑ Effects of actual policy proposals can be compared to the Ricardian Equivalence benchmark
- ❑ At aggregate level, total tax collections sometime “seem” lump-sum (i.e., independent of aggregate macroeconomic activity)



- ❑ Ricardian Equivalence
 - ❑ Is a theoretical benchmark
 - ❑ Is an empirical benchmark
- } Ricardian Equivalence is about the (lack of) effects of *changes in tax policy*, holding total government liabilities fixed. If g_1 and/or g_2 change, Ric. Equiv. does *not* apply.

INFINITE-PERIOD ECONOMY

FEBRUARY 23, 2009

Introduction

BASICS

- ❑ Modern workhorse macroeconomic models feature an **infinite** number of periods
 - ❑ A more realistic (?) view of time
- ❑ Especially useful for thinking about asset accumulation and asset pricing
 - ❑ The intersection of modern macro theory and modern finance theory

February 23, 2009

30

BASICS

- ❑ Modern workhorse macroeconomic models feature an **infinite** number of periods
 - ❑ A more realistic (?) view of time
- ❑ Especially useful for thinking about asset accumulation and asset pricing
 - ❑ The intersection of modern macro theory and modern finance theory
- ❑ Here, assume just one **real** asset
 - ❑ Call it a “stock” – i.e., a share in the S&P 500
 - ❑ (In Chapter 14, two nominal assets: bonds and money)

BASICS

- ❑ Modern workhorse macroeconomic models feature an **infinite** number of periods
 - ❑ A more realistic (?) view of time
- ❑ Especially useful for thinking about asset accumulation and asset pricing
 - ❑ The intersection of modern macro theory and modern finance theory
- ❑ Here, assume just one **real** asset
 - ❑ Call it a “stock” – i.e., a share in the S&P 500
 - ❑ (In Chapter 14, two nominal assets: bonds and money)
- ❑ Index time periods by arbitrary indexes t , $t+1$, $t+2$, etc.
 - ❑ **Important: all of our analysis will be conducted from the perspective of the very beginning of period t ...**
 - ❑ **...so an “infinite future” (period $t+1$, period, $t+2$, period $t+3$, ...) for which to save**

BASICS

□ Timeline of events



□ Notation

- c_t : consumption in period t
- P_t : nominal price of consumption in period t
- Y_t : nominal income in period t ("falls from the sky")
- a_{t-1} : real wealth (stock) holdings at beginning of period t /end of period $t-1$

February 23, 2009

 a_{t-1} Economic events during
period t : income,
consumption, savings a_t Economic
period t
consumpPeriod t

Peri

BASICS

□ Timeline of events



□ Notation

- c_t : consumption in period t
- P_t : nominal price of consumption in period t
- Y_t : nominal income in period t ("falls from the sky")
- a_{t-1} : real wealth (stock) holdings at beginning of period t /end of period $t-1$
- S_t : nominal price of a unit of stock in period t
- D_t : nominal dividend paid in period t by each unit of stock held at the start of t

The "defining
features" of
stock

February 23, 2009

34

BASICS

Timeline of events



Notation

- c_t : consumption in period t
 - P_t : nominal price of consumption in period t
 - Y_t : nominal income in period t ("falls from the sky")
 - a_{t-1} : real wealth (stock) holdings at beginning of period t /end of period $t-1$
 - S_t : nominal price of a unit of stock in period t
 - D_t : nominal dividend paid in period t by each unit of stock held at the start of t
 - π_{t+1} : net inflation rate between period t and period $t+1$
- $$\pi_{t+1} = \frac{P_{t+1} - P_t}{P_t} \left(= \frac{P_{t+1}}{P_t} - 1 \right)$$

- y_t : real income in period t ($= Y_t/P_t$)

 a_{t-1} Economic events during
period t : income,
consumption, savings a_t Economic
period t
consump

February 23, 2009

Period t

Peri

BASICS

Timeline of events



Notation

- c_{t+1} : consumption in period $t+1$
- P_{t+1} : nominal price of consumption in period $t+1$
- Y_{t+1} : nominal income in period $t+1$ ("falls from the sky")
- a_t : real wealth (stock) holdings at beginning of period $t+1$ /end of period t
- S_{t+1} : nominal price of a unit of stock in period $t+1$
- D_{t+1} : nominal dividend paid in period t by each unit of stock held at the start of $t+1$
- π_{t+2} : net inflation rate between period $t+1$ and period $t+2$

$$\pi_{t+2} = \frac{P_{t+2} - P_{t+1}}{P_{t+1}} \left(= \frac{P_{t+2}}{P_{t+1}} - 1 \right)$$

- y_{t+1} : real income in period $t+1$ ($= Y_{t+1}/P_{t+1}$)

February 23, 2009

36

BASICS

- Timeline of events



- Notation

- And so on for period $t+2$, $t+3$, etc...

February 23, 2009

a_{t-1}

Economic events during
period t - income,
consumption, savings

a_t

Economic
period t
consump

Period t

Peri

SUBJECTIVE DISCOUNT FACTOR

- Infinite number of periods a more serious view of time
- **Impatience** potentially an issue when taking a serious view of time

February 23, 2009

38

SUBJECTIVE DISCOUNT FACTOR

- ❑ Infinite number of periods a more serious view of time
- ❑ **Impatience** potentially an issue when taking a serious view of time
- ❑ Individuals (i.e., consumers) are impatient
 - ❑ All else equal, would rather have outcome X today than identical outcome X at some future date
 - ❑ An introspective statement about the world
 - ❑ An empirical statement about the world

SUBJECTIVE DISCOUNT FACTOR

- ❑ Infinite number of periods a more serious view of time
- ❑ **Impatience** potentially an issue when taking a serious view of time
- ❑ Individuals (i.e., consumers) are impatient
 - ❑ All else equal, would rather have outcome X today than identical outcome X at some future date
 - ❑ An introspective statement about the world
 - ❑ An empirical statement about the world
- ❑ Subjective discount factor
 - ❑ A simple model of consumer impatience
 - ❑ **β (a number between zero and one) measures impatience**
 - ❑ The lower is β , the less does individual value future utility

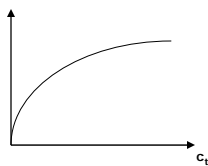
SUBJECTIVE DISCOUNT FACTOR

- ❑ Infinite number of periods a more serious view of time
- ❑ **Impatience** potentially an issue when taking a serious view of time
- ❑ Individuals (i.e., consumers) are impatient
 - ❑ All else equal, would rather have outcome X today than identical outcome X at some future date
 - ❑ An introspective statement about the world
 - ❑ An empirical statement about the world
- ❑ Subjective discount factor
 - ❑ A simple model of consumer impatience
 - ❑ β (a number between zero and one) measures impatience
 - ❑ The lower is β , the less does individual value future utility
 - ❑ Simple assumption about how "impatience" builds up over time
 - ❑ Multiplicatively: i.e., discount one period ahead by β , discount two periods ahead by β^2 , discount three periods ahead by β^3 , etc.
 - ❑ Do individuals' impatience really build up over time in this way?...limited empirical evidence so really don't know...

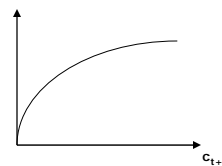
UTILITY

- ❑ Preferences $v(c_t, c_{t+1}, c_{t+2}, \dots)$ with all the "usual properties"
 - ❑ **Lifetime utility function**
 - ❑ Strictly increasing in $c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots$
 - ❑ Diminishing marginal utility in $c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots$

$v(c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots)$



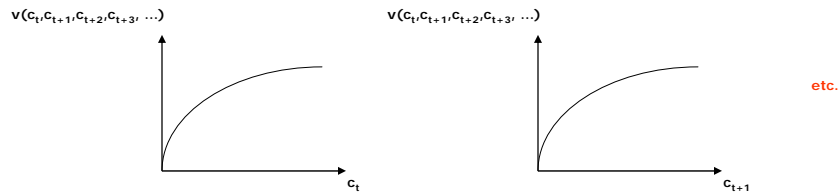
$v(c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots)$



etc.

UTILITY

- Preferences $v(c_t, c_{t+1}, c_{t+2}, \dots)$ with all the “usual properties”
 - **Lifetime utility function**
 - Strictly increasing in $c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots$
 - Diminishing marginal utility in $c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots$

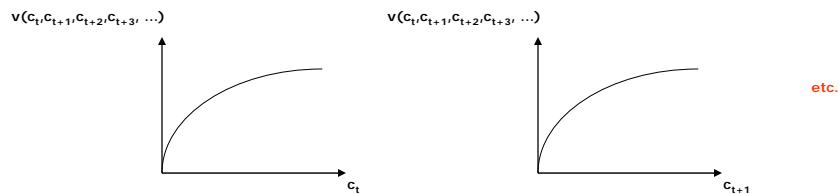


- Lifetime utility function additively-separable across time (a simplifying assumption), starting at time t

$$v(c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots) = u(c_t) + \beta u(c_{t+1}) + \beta^2 u(c_{t+2}) + \beta^3 u(c_{t+3}) + \dots$$

UTILITY

- Preferences $v(c_t, c_{t+1}, c_{t+2}, \dots)$ with all the “usual properties”
 - **Lifetime utility function**
 - Strictly increasing in $c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots$
 - Diminishing marginal utility in $c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots$



- Lifetime utility function additively-separable across time (a simplifying assumption), starting at time t

$$v(c_t, c_{t+1}, c_{t+2}, c_{t+3}, \dots) = u(c_t) + \beta u(c_{t+1}) + \beta^2 u(c_{t+2}) + \beta^3 u(c_{t+3}) + \dots$$

- **Utility side of infinite-period model no different than Chapter 1 model – except no longer possible to represent graphically...**