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Acknowledgements

This document has evolved over the years with contributions from: Laurence Ales, Nicolas Petrosky-Nadeau, Chris Sleet, Sevin Yeltekin.

Invaluable feedback was also provided by students of 73-240 at Carnegie Mellon’s Tepper School of Business. And by the numerous teaching assistants of those classes.

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Some graphs and diagrams are taken from:

2. Hoover, Applied Intermediate Macroeconomics
3. Abel, Bernanke, Croushore, Macroeconomics.
5. Acemoglu, Introduction to modern economic growth.
Part I

Syllabus
73-240 – Intermediate Macroeconomics

Prof. Laurence Ales

Instructor: Laurence Ales
E-mail: ales@cmu.edu
Class Web: Blackboard
Office: GSIA 328
Office Hours: Th 3:30-5:30

TA 1: Antonio Andres Bellofatto
E-mail: andresb@cmu.edu
Section A: F 1:30-2:20 POS MN AUD
Office Hours: GSIA 301 T 1:30-3:30

TA 2: Minyoung Rho
E-mail: mrho@andrew.cmu.edu
Section B: F 1:30-2:20 WEH 5421
Office Hours: GSIA 310 Th 1:30-3:30

Class times: MW 01:30PM 02:50PM in POS MN AUD

Textbook:
Stephen D. Williamson: Macroeconomics, 5/E
ISBN-10: 0132991330
Publisher: Addison-Wesley
Copyright: 2013

Learning objectives:

By the end of this course the student will be able to...

1. Understand and be able to use the various measures of an aggregate economy’s performance and well-being;

2. Be able to perform simple forecast of macroeconomic variables;
3. ...Understand how aggregate macroeconomic behavior is affected by microeconomic behavior and equilibrium restrictions;

4. ...Be able to answer simple macroeconomic policy questions by formulating a model, finding the data and deriving an analytical and quantitative answer;

5. ...Understand the factors that cause economic growth and be able to describe the patterns of economic development across countries and over time;

6. ...Understand how credit and labor frictions operate and how they might impact macroeconomic behavior.

Course Description:

The goal of this course is to provide a rigorous framework for understanding modern macroeconomics. The study of the macroeconomy will be divided in two fronts: theory and data. The theory part will focus in constructing and analyzing the benchmark “workhorse” modern macroeconomic model. This model will be casted both in a short run and long run version. The short run version will allow us to study policies that are often discussed in the media and the political arena; the long run version will allows us to understand what is behind the phenomenon of growth observed in the last three centuries. The data part of the course will focus on studying actual macroeconomic U.S. data. The study will be both of empirical in nature: studying past data and forecasting future behavior; and quantitative in nature building a tight link between the macroeconomic model and the data.

Prerequisites:

Formal: (73100) and (73230) and (21120) and (21259 or 21256 or 21268 or 21269).

Informal: In the homework I will ask for extensive data work. I advice you to learn a spreadsheet software (i.e. Excel, Google docs) as soon as possible. Also, I will require the homework to be typed, now is a good time to brush up your typing skills! Finally I expect you to be able to apply basic tools of mathematics, statistics and economics.

Course material:

Textbook: The textbook will be used as a guide and a reference book. I adopt the organization of the book, but do not follow it verbatim. The fourth edition of the book is also an
acceptable version.

An additional textbook that I will occasionally cite in the slides (this book is not required) is: *Applied Intermediate Macroeconomics* by Kevin Hoover.

**Twitter and other News:** This year I will experiment with Twitter. The class official twitter feed is [@cmu73240](http://twitter.com/cmu73240). In this feed I will post class announcements (that will be mirrored in the Blackboard website) and interesting macroeconomic news. Every week, as a form of “digest”, I will summarize the most relevant macroeconomics news at the beginning of class.

**Slides:** I will make slides available on the class Blackboard website. However, I will not make the slides available before class. This is done to encourage discussion during class. In particular, not posting slides before classes allows me to ask questions that might otherwise be answered by looking at the next slide. During the semester I will also prepare the slides in book format. The idea is for you to have a document that you might keep for years to come.

**Blackboard:** I will make some additional material available on the class website: unless I specify otherwise these are not a required reading (but most of the times are very interesting!). Check Blackboard regularly: the TAs and I will use the site to communicate additional information to you, to post slides and update the syllabus.

**Feedback and Email:**

Together with the usual evaluation forms, I set up an on-line, live, anonymous feedback system, you can access it here: [http://tinyurl.com/evaluations-ales](http://tinyurl.com/evaluations-ales)

This is a large class, in order to communicate more efficiently I will follow the following email policy:

- During the week, I will answer student emails usually within 24 hours.
- Usually I will not be able to answer homework emails the night before they are due!
- Any regrading request must be submitted to your TA first. If an issue persists I will be happy to help after that.
Requirements and Grades:

**Final Grade**: The final grade will be computed according to the following components:

- 6 assignments (30% of total grade)
- 2 midterms (35% of total grade). Note that no midterm will be dropped.
- 1 comprehensive final exam (25% of total grade).
- 10% for attendance and class participation. I will have random roll calls during the semester.

Final grades will be determined on a relative basis: students with the highest total points will receive A’s, those next in line will receive B’s, etc. I will not disclose cutoff values.

The class will feature instant quizzes during classes. These non-graded quizzes will be anonymous and will be used to sample your knowledge of the material we will cover in class. Instead of using a clicker system I decided to administer quizzes via a web version that you can access from your phone (this will save you the cost of buying a clicker). The form can be accessed here: [http://tinyurl.com/73240-ales](http://tinyurl.com/73240-ales) so make sure to bookmark it!

Additional Policies:

1. Students with Disabilities: If you have a disability, let me know as soon as possible and contact the Office of Disability Resource to request appropriate accommodation.

2. Class room behavior: Private conversations, browsing the web and checking email will be considered inappropriate. If you do it, you will be cold called.

3. Final score regrading: any regrading request must be submitted to the economics program at the beginning of the fall semester.

4. Class Material: I will provide lectures slides, notes etc. These materials are subject to copyright and are being provided for the personal educational use by students enrolled in this course. Any other use, including further reproduction and distribution of the materials (whether in hard copy or electronic form) is strictly prohibited. For example, you may not copy any of these materials and upload them to any other web sites without the prior permission of the applicable copyright holder.

Homeworks Policies:
1. Turning in Homework: Homework must be turned in on the day it is due (usually on a Friday) your TA will collect the homework in class. Late homework will NOT be accepted unless you are sick and have a doctor’s note.

2. Homework regrading: If you believe a question has been incorrectly graded, please take your homework to your TA within 2 weeks of it being returned.

3. Working in groups: You may work in groups of up to 4. BUT: You MUST put names of other group members on your homework. You MUST write up your own set of answers. Do NOT simply copy some other person’s work. Copied homework will result in receiving zero points for that homework as a minimum sanction.

4. TYPE your work. Equations may be hand written. Write your first and last name on the title of each graph. Graphs that do not contain data may be hand drawn.

5. Buy a stapler!

Schedule

Important dates:

- Midterms on Feb 24th and Apr 9th.
- Final exam date: TBA
  (for updates check: http://www.cmu.edu/hub/).
- Grades posted by May 15th.

The following is a tentative schedule, refer to Blackboard for updates on dates and topics.
<table>
<thead>
<tr>
<th>Week</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Jan 13) Introduction</td>
<td>(Jan 15) Measurement: levels and GDP</td>
<td>(Jan 17)</td>
</tr>
<tr>
<td>2</td>
<td>(Jan 20) No class - MLK day</td>
<td>(Jan 22) Nominal and real Quantities; Measurement: fluctuations</td>
<td>(Jan 24)</td>
</tr>
<tr>
<td>3</td>
<td>(Jan 27) Introduction to Forecasting</td>
<td>(Jan 29) The Consumer</td>
<td>(Jan 31)</td>
</tr>
<tr>
<td>4</td>
<td>(Feb 3) The Consumer</td>
<td>(Feb 5) The Firm</td>
<td>(Feb 7)</td>
</tr>
<tr>
<td>5</td>
<td>(Feb 10) The Firm</td>
<td>(Feb 12) The Government</td>
<td>(Feb 14)</td>
</tr>
<tr>
<td>6</td>
<td>(Feb 17) Equilibrium and Pareto optimality</td>
<td>(Feb 19) Taxation and spending</td>
<td>(Feb 21)</td>
</tr>
<tr>
<td>7</td>
<td>(Feb 24) MIDTERM 1</td>
<td>(Feb 26) Growth facts</td>
<td>(Feb 28)</td>
</tr>
<tr>
<td>8</td>
<td>(Mar 3) Growth: Malthus</td>
<td>(Mar 5) Growth: Solow</td>
<td>(Mar 7) No class</td>
</tr>
<tr>
<td>9</td>
<td>(Mar 10) Spring Break</td>
<td>(Mar 12) Spring Break</td>
<td>(Mar 14) No class</td>
</tr>
<tr>
<td>10</td>
<td>(Mar 17) Growth: endogenous growth</td>
<td>(Mar 19) Saving and Investment</td>
<td>(Mar 21)</td>
</tr>
<tr>
<td>11</td>
<td>(Mar 24) Inter-temporal model</td>
<td>(Mar 26) Inter-temporal model: Policy</td>
<td>(Mar 28)</td>
</tr>
<tr>
<td>12</td>
<td>(Mar 31) Finance and macro</td>
<td>(Apr 2) Finance and macro</td>
<td>(Apr 4)</td>
</tr>
<tr>
<td>13</td>
<td>(Apr 7) Review</td>
<td>(Apr 9) MIDTERM 2</td>
<td>(Apr 11) No class</td>
</tr>
<tr>
<td>14</td>
<td>(Apr 14) Money</td>
<td>(Apr 16) Monetary model</td>
<td>(Apr 18) No class</td>
</tr>
<tr>
<td>16</td>
<td>(Apr 28) Unemployment, wages</td>
<td>(Apr 30) Final Review</td>
<td>(May 2)</td>
</tr>
</tbody>
</table>

This version: January 11, 2014
Part II

Class Notes
Chapter 1

Introduction and Methodology
About Myself

My name is: Laurence Ales

- Born in Italy
- B.S. in Physics
- Ph.d. in Economics
- Joined CMU in 2008, as an Assistant Professor of Economics

My research:
- How much inequality in consumption and health should there be?
- How much insurance do workers have?
- How should we tax people?

The Syllabus

- Make sure to get and read the syllabus!

Details About the Course

- The class: MW 1:30-2:50

- TA and Recitation:
  - Antonio Andres Bellofatto
  - Minyoung Rho

- Office Hours:
  - Ales: Th 3:30-5:30
  - Bellofatto : T 1.30-3.30
  - Rho: Th 1:30-3:30

- The textbook:
  - Macroeconomics - S. Williamson 5/E
Hw, Grading and Exams

- 6 Homework - 30% of grade
- 2 Midterms (tentative: Feb 24th; Apr 9th) - 35% of grade
- 1 Final - 25% of grade (check CMU website for dates)

- 10% for attendance and participation
- No midterm dropped
- No mercy for cheating!
- Grade me:
  - Online, live, anonymous feedback system:
    - http://tinyurl.com/evaluations-ales

Recommendations I/II

- Email: for regrading email your TAs first!
- Microeconomics!!
- Math
  - Find $x$: $\log(x + 1) - \log(x + 2) = \log\left(\frac{1}{x}\right)$.
  - Find $x$: $\max_x f(x)$ s.t. $g(x) = 0$.

Recommendations II/II

- Data Analysis:
  - We will extensively work with data, review your stats class.
  - Excel was released in 1985! You should be able (soon) to:
    1. Manipulate data;
    2. Perform simple manipulations on data;
    3. Plot a (nice looking) graph!
A Bad Graph

• How many bad graphical habits can you spot in this graph?

Twitter and News

• The class official twitter feed is @cmu73240.

• In this feed I will post:
  1. Class announcements
     (that will be mirrored in the Blackboard website).

• Every week, as a form of “digest”, I will summarize the most relevant macroeconomics news at the beginning of class.

Let’s Start!
1 What is this course about?

2 Notes on Methodology.
What Are We Going To Study?

- What does Macroeconomics study?
  - From Semantics: large economics systems.
  - (Hoover) *Is the study of the economy taken as a whole; whereas Microeconomics is the study of a part of the economy, taking the remainder as given.*

- What type of questions does it try to answer?
  - What will GDP be one year from now?
  - How do economic fluctuations come about?
    - What can we (Government, Fed) do about it?
  - Why is the US richer than most countries?
    - How does policy affect growth?
  - How should taxes and government debt be used?

What Do You Want From This Course?

1. Understand and perform simple forecasts of various measures of an aggregate economy’s performance;
2. Understand how aggregate macroeconomic behavior is affected by microeconomic behavior and equilibrium restrictions;
3. Be able to answer simple macroeconomic policy questions by formulating a model, finding the data and deriving an analytical and quantitative answer;
4. Understand the factors that cause economic growth and be able to describe the patterns of economic development over time;
5. Understand how credit and labor frictions operate and how they might impact macro economic behavior.
**Methodology**

**Normative vs. Positive Questions**

- Economics is interested in two types of fundamental questions. These questions can be either positive or normative.

- **Positive questions**: questions independent of any ethical or moral consideration. Focused on “what was/is/will be”. These questions rely on an objective investigation of data.

- **Normative questions**: questions that deal with the notion of “what should be”. These questions rely on completely specified set of ethical and social goals.

- The “hard” sciences only deal with positive questions. (just for fun try and ask a “normative” physics question!)

**How Do We Get The Answers?**

- Economists similarly to “hard” scientists like to build **THEORIES**.

  Why? **GOOGLE: PITCH DROP EXPERIMENT**

  ...experiments can take a long time!

  ...but that is not the only reasons we build theories...
• Milton Friedman:

_The ultimate goal of a positive science is the development of a “theory” or, “hypothesis” that yields valid and meaningful (i.e., not truistic) predictions about phenomena not yet observed. Such a theory is, in general, a complex intermixture of two elements. In part, it is a “language” designed to promote “systematic and organized methods of reasoning.” In part, it is a body of substantive hypotheses designed to abstract essential features of complex reality._

• A theory should:
  - be a language to help us communicate.
  - provide simplifying assumptions that help understand reality.

---


---

How Do We Get The Answers?

• A fundamental difference between an economist and a hard scientist is what to do when a theory has been formulated.

• Can economists follow closely the Scientific Method?

  **Karl Popper** on the Scientific Method:

_ A theory which is not refutable by any conceivable event is non-scientific. Irrefutability is not a virtue of a theory (as people often think) but a vice. [...] Every genuine test of a theory is an attempt to falsify it, or to refute it. **Testability is falsifiability.**

---


---

The Problem With the Scientific Method

• Falsifiability might be impossible: people and firms are smart, a controlled “experiment” might be impossible to achieve.

• Socially, falsifiability may not be very desirable!
Building a Model

- A theory written by an economist is simply a “model”.
- What is a model? A simple virtual representation of a real environment.
- Some examples:
  - Google maps $\leftrightarrow$ The world
  - $F = g(m_1 \cdot m_2)/d^2$ $\leftrightarrow$ An apple falling from a tree
  - A macroeconomic model $\leftrightarrow$ The U.S. economy
- What makes a good model? It must be simple enough so that we can learn from it!

The Issue of Realism

- Models, by definition, are simplified representations of reality.
- It is common for economic models to be criticized on the basis of being “unrealistic”.
- Should we be concerned about these type of critiques? If the “unrealistic” assumptions made in the model drastically changes the results: YES.
- If not, the model should not be evaluated on the basis of realism but on their predictive power.
- This approach is also common in the sciences: think for example the model that Newton considered when thinking of an apple falling from the tree.

Model Ingredients

- Actors:
  - Households
  - Firms
  - Markets
  - Government
- Quantities:
  - Households: Consumption, Savings, Hours worked
  - Firm: Output, Vacancies
  - Markets: Prices, Inflation
  - Government: Taxes, Debt, Expenditures
Roadmap

This week ⇒ Study quantities: GDP, Consumption...

Next week ⇒ Study fluctuations in the data

After that... ⇒ Modeling: household, firm and government
Chapter 2

Measurement
2.1 GDP
A KEY QUANTITY: GDP

Gross Domestic Product

Important definition!

Gross domestic product (GDP):
The market value of final goods and services produced within a country in a given period (usually a year).

Next we look at:

• GDP across countries;
• GDP over time for the U.S.

GDP Across Countries

What are potential issues in comparing GDP across countries:

1. We need a unit of measure: U.S. dollar;
2. If we care about relative richness, we need to scale per capita;
3. Need to adjust for relative cost of living: power purchasing parity (PPP).
Comparing the price of a Big Mac around the world:

<table>
<thead>
<tr>
<th>Country</th>
<th>Price in USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>$ 4.56</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$ 6.72</td>
</tr>
<tr>
<td>China</td>
<td>$ 2.61</td>
</tr>
<tr>
<td>Euro Area</td>
<td>$ 4.66</td>
</tr>
<tr>
<td>India</td>
<td>$ 1.50</td>
</tr>
<tr>
<td>Norway</td>
<td>$ 7.51</td>
</tr>
</tbody>
</table>

Data: July 2013. Source: http://www.economist.com/content/big-mac-index

Appendix: Data

Where To Find Data:

- **National:**
     (check out their mobile apps!)

- **International:**
  1. Penn World Tables: http://pwt.sas.upenn.edu

GDP Per Capita Across Countries


<table>
<thead>
<tr>
<th>Country</th>
<th>Amount (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>$ 49,922</td>
</tr>
<tr>
<td>Canada</td>
<td>$ 52,231</td>
</tr>
<tr>
<td>Italy</td>
<td>$ 33,115</td>
</tr>
<tr>
<td>Mexico</td>
<td>$ 10,247</td>
</tr>
<tr>
<td>Nigeria</td>
<td>$ 1,630</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>$ 482</td>
</tr>
<tr>
<td>China</td>
<td>$ 6,075</td>
</tr>
<tr>
<td>India</td>
<td>$ 1,491</td>
</tr>
</tbody>
</table>

HUGE cross country differences: Rich/Poor > 40 !!
How about countries over time?
In looking at GDP over time we must take care of one thing...

Prices grow, we need to rescale at a common value: for example choose $1 in 2000.

Check here for “what is a dollar worth calculator”:
http://www.minneapolisfed.org/

A curiosity:

U.S. real GDP (in 2000 dollars) 1900 - 2013

Source: Officer, Williamson (2012).
Data Link: http://www.measuringworth.com/datasets/usgdp12/
Some observations:

1. It grows;
2. It fluctuates;
3. There are some big fluctuations, some are “exogenous”.

A question to think about... is it growing faster?

U.K. GDP Over Time

U.K. Real GDP (in 2006 GBP) 1830 - 2009:

![Graph showing Real GDP of England (Billions of 2006 Pounds) from 1830 to 2009.]

Source: Bank of England

History of GDP

- Developed by Simon Kuznets and his team in 1934 (once released, data was already 2 years old!)
- First estimate using IRS data and 1929 Census (he measured the national income)
- In 1940 government interested in measuring national production (estimated with: final sales, consumption spending, shipments...)
- In 1960s first value added estimates (estimated with the aid of input-output tables)
Who Computes GDP Today?

- The Bureau of economic analysis (BEA) periodically publishes the National Income and Product Accounts (NIPA). They contain:
  1. GDP and its components (more on these later)
  2. GDP by state, metropolitan area
  3. GDP by industry (I-O tables)
  4. International accounts (balance of payments)

- You can get all the data here: http://www.bea.gov

- BEA uses data from: Census, Bureau of labor statistics (surveys), Tax returns, Industry estimates...

- BEA releases three versions of its estimates: Advance, Preliminary, Final.

3 “Definitions” of GDP

BEA uses 3 alternative definitions/approaches to GDP:

- **Expenditure Approach**: Total spending on newly produced final goods and services produced within a nation during a year.

- **Income Approach (national income)**: Total Income generated by newly produced final production goods and services, profits and taxes paid by firms and depreciation of capital within a nation during a year.

- **Product Approach (value added)**: Market value of final goods and services newly produced within a nation during a year.

We will use the symbol $Y$ to denote either total expenditure, income or value added!

### 3 Definitions of GDP (2005 Data)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Three Ways to Measure GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Value-added (or production) approach</strong></td>
<td>2005 share (percent)</td>
</tr>
<tr>
<td>Gross Output (gross sales less change in inventories)</td>
<td>183.5</td>
</tr>
<tr>
<td>Less: Intermediate inputs</td>
<td>83.5</td>
</tr>
<tr>
<td>Equals: Value added for each industry</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>II. Income (by type) approach</strong></td>
<td></td>
</tr>
<tr>
<td>Sum of: Compensation</td>
<td>56.6</td>
</tr>
<tr>
<td>Rental income</td>
<td>0.8</td>
</tr>
<tr>
<td>Profits and proprietors’ income</td>
<td>17.6</td>
</tr>
<tr>
<td>Taxes on production &amp; imports</td>
<td>7.4</td>
</tr>
<tr>
<td>Less: Subsidies</td>
<td>0.5</td>
</tr>
<tr>
<td>Interest, miscellaneous payments</td>
<td>5.5</td>
</tr>
<tr>
<td>Depreciation</td>
<td>12.9</td>
</tr>
<tr>
<td>Equals: Total domestic incomes earned</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>III. Final demand (or expenditures) approach</strong></td>
<td></td>
</tr>
<tr>
<td>Sum of: Consumption of final goods and services by households</td>
<td>70.0</td>
</tr>
<tr>
<td>Government expenditures on goods and services</td>
<td>19.0</td>
</tr>
<tr>
<td>Net exports of goods and services (exports − imports)</td>
<td>−5.7</td>
</tr>
<tr>
<td>Equals: Final sales of domestic product to purchasers</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The Components of GDP: Expenditure Approach

GDP is comprised by:

- **Consumption expenditures** (C): consumer goods and services
- **Investment** (I): goods produced but not consumed
- **Government expenditures** (G)
- **Net exports** (NX): goods and services exported minus goods and services imported

\[ GDP = Y = C + I + G + NX \]

The Components of Nominal GDP in 2012/2013

<table>
<thead>
<tr>
<th>Line</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>1. Gross domestic product</td>
<td>18,914.5</td>
<td>18,996.4</td>
</tr>
<tr>
<td>2. Personal consumption expenditure</td>
<td>13,150.8</td>
<td>13,212.2</td>
</tr>
<tr>
<td>3. Private durable goods</td>
<td>1,711.1</td>
<td>1,731.6</td>
</tr>
<tr>
<td>4. Durable goods</td>
<td>1,156.3</td>
<td>1,158.5</td>
</tr>
<tr>
<td>5. Non-durable goods</td>
<td>612.2</td>
<td>612.2</td>
</tr>
<tr>
<td>6. Services</td>
<td>5,743.3</td>
<td>6,046.2</td>
</tr>
<tr>
<td>7. Gross private domestic investment</td>
<td>2,482.8</td>
<td>2,615.2</td>
</tr>
<tr>
<td>8. Residential</td>
<td>1,180.9</td>
<td>1,180.9</td>
</tr>
<tr>
<td>9. Nonresidential</td>
<td>1,219.9</td>
<td>1,219.9</td>
</tr>
<tr>
<td>10. Structures</td>
<td>463.1</td>
<td>463.1</td>
</tr>
<tr>
<td>11. Equipment</td>
<td>270.4</td>
<td>270.4</td>
</tr>
<tr>
<td>12. Intellectual property products</td>
<td>216.0</td>
<td>216.0</td>
</tr>
<tr>
<td>13. Nonresidential</td>
<td>476.4</td>
<td>476.4</td>
</tr>
<tr>
<td>14. Change in private inventories</td>
<td>102.5</td>
<td>102.5</td>
</tr>
<tr>
<td>15. Net exports of goods and services</td>
<td>203.8</td>
<td>237.0</td>
</tr>
<tr>
<td>16. Goods</td>
<td>2,174.5</td>
<td>2,187.6</td>
</tr>
<tr>
<td>17. Services</td>
<td>1,180.9</td>
<td>1,180.9</td>
</tr>
<tr>
<td>18. Government consumption expenditure</td>
<td>1,552.7</td>
<td>1,552.7</td>
</tr>
<tr>
<td>19. National defense</td>
<td>801.5</td>
<td>801.5</td>
</tr>
<tr>
<td>20. Public order and safety</td>
<td>475.2</td>
<td>475.2</td>
</tr>
<tr>
<td>21. State and local government</td>
<td>2,075.7</td>
<td>2,075.7</td>
</tr>
</tbody>
</table>

Some observations:

1. Consumption is the largest component 2/3 of GDP
2. Government is around 15/20% of GDP
3. Net export is negative
4. Services is the largest component of consumption
5. Nonresidential investment is the largest component of investment

Table 1.1.5 from NIPA (values are Billions of $)

The Components of Nominal GDP in 2012/2013

32 of 260
An Example: The Island Economy

The Expenditure Approach

- Determine all expenditure by each agent and add government expenditures:
  \[ \text{Total expenditures} = C + I + G + NX \]

- Note: in this example by definition \( G = NX = 0 \)

- Note: in our example some coconuts are sold to the restaurant some are sold directly.

- Note: government expenditures in our example are only for labor services, so consider wages as expenditure.
### An Example: The Island Economy

<table>
<thead>
<tr>
<th></th>
<th>Coconut Producer</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Revenue</td>
<td>$20 million</td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>$5 million</td>
<td>$5.5 million</td>
</tr>
<tr>
<td>Interest on Loan</td>
<td>$0.5 million</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>$1.5 million</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Restaurant</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Revenue</td>
<td>$30 million</td>
<td></td>
</tr>
<tr>
<td>Cost of Coconuts</td>
<td>$12 million</td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>$4 million</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>$3 million</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Wage Income</th>
<th>Interest Income</th>
<th>Taxes</th>
<th>Profits Distributed from Producers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>$14.5 million</td>
<td>$0.5 million</td>
<td>$1 million</td>
<td>$24 million</td>
</tr>
</tbody>
</table>

**Expenditure approach:**

\[
\text{GDP} = \text{Buy coconut } + \text{Buy Meal } + \text{Government } = 8 + 30 + 5.5 = 43.5
\]

**The Income Approach**

Determine all income for each agent:

- For HH: wages + profits from firms + interests;
- For Government: taxes payed by firms.

<table>
<thead>
<tr>
<th></th>
<th>Coconut Producer</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>Wages</td>
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</tr>
<tr>
<td>Interest on Loan</td>
<td>$0.5 million</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>$1.5 million</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Wages</td>
<td>$4 million</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>$3 million</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Wage Income</th>
<th>Interest Income</th>
<th>Taxes</th>
<th>Profits Distributed from Producers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Income approach:**

\[
\text{GDP} = \text{Wages} + \text{Interests} + \text{Profits} + \text{Taxes from firms } = 14.5 + 0.5 + 24 + 4.5 = 43.5
\]
The Product Approach

Determine the final product by determining the valued added of each firm and add government expenditures:

- **Note 1:** the sum of value added equals the value of final products
- **Note 2:** what is the valued added of the government? (use value of inputs)

An example: The Island Economy

<table>
<thead>
<tr>
<th>Coconut Producer</th>
<th>Restaurant</th>
<th>Consumer</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Revenue</td>
<td>$20 million</td>
<td>$30 million</td>
<td>$14.5 million</td>
</tr>
<tr>
<td>Wages</td>
<td>$5 million</td>
<td>$12 million</td>
<td>$0.5 million</td>
</tr>
<tr>
<td>Interest on Loan</td>
<td>$0.5 million</td>
<td>$4 million</td>
<td>$1 million</td>
</tr>
<tr>
<td>Taxes</td>
<td>$1.5 million</td>
<td>$3 million</td>
<td>$24 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tax Revenue</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wages</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$5.5 million</td>
</tr>
</tbody>
</table>

Product approach:

\[
GDP = \underbrace{\$20}_{\text{Coconut Producer}} + \underbrace{(30 - 12)}_{\text{Restaurant}} + \underbrace{\$5.5}_{\text{Government}} = \$43.5
\]

National Accounting Identities
• The 3 definitions of GDP are useful to relate production and income (there is always income related to any value added or production!)

• Another important relation is the disposable income identity: (The idea is to relate income to its disposition by households)

\[ Y - T + TR = C + S \]

\( Y \) - Taxes \( + \) Transfers \( = \) Consumption \( + \) Saving

\[ Y = C + I + G + NX \]

Disposable Income id.

GDP Definition

• Using the definition of GDP and the disposable income identity we can identify which sector is running a surplus or deficit

\[ Y - T + TR = C + S; \]

\[ Y = C + I + G + NX \]

Disposable Income id.

GDP Definition

• Substitute out \( Y \) and re-arrange:

\[ G - T + TR + I - S + NX = 0 \]

Government Deficit \( + \) Private Sector Deficit \( + \) Foreign Sector Deficit

Not every sector can run a surplus, or deficit!

---

The Sectoral Deficit Identity

---

The Limits of GDP
Problems With GDP

What is GDP not counting in measuring the size of the economy?

1. Non-market production:
   - Home production (think about housework, childcare, DIY)
   - In developing countries: subsistence farmers
     (living with 1$ a day means that most of the crops are for own consumption, few sold for cash)

2. Underground economy

What does GDP mean?

1. What about environmental costs?
2. What about welfare?

Underground Economy Across Countries


<table>
<thead>
<tr>
<th>Country</th>
<th>Fraction of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>77%</td>
</tr>
<tr>
<td>Thailand</td>
<td>70%</td>
</tr>
<tr>
<td>Bolivia</td>
<td>67%</td>
</tr>
<tr>
<td>Italy</td>
<td>27%</td>
</tr>
<tr>
<td>U.S.</td>
<td>10%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>9%</td>
</tr>
</tbody>
</table>

Measuring the Underground Economy

- Direct Approaches:
  - Surveys;
  - Tax audits.

- Indirect Approaches:
  - National accounting statistics;
  - Labor force statistics;
  - Transactions;
  - Currency demand;
  - Electricity consumption and other inputs.
- A “bad” is a good that the more you have of it, the less happy you are about it.

- GDP measures “goods”, by definition bads are not included. In comparing the state of two economies across time and space we should also consider:
  - Pollution;
  - Depletion of natural resources.

---

Interpreting GDP: Hours

Is GDP measuring *welfare*?

- Leisure, health care, education...

Source: OECD.

---

Interpreting GDP: Inequality

- How about inequality?
  - GDP is a sum, contains no information on distribution of consumption/income.

- Interdecile (P90/P10) ratio across countries:

<table>
<thead>
<tr>
<th>Country in 2010</th>
<th>P90/P10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>2.72</td>
</tr>
<tr>
<td>France</td>
<td>3.39</td>
</tr>
<tr>
<td>U.K.</td>
<td>4.21</td>
</tr>
<tr>
<td>Italy</td>
<td>4.31</td>
</tr>
<tr>
<td>U.S.</td>
<td>5.91</td>
</tr>
<tr>
<td>Mexico</td>
<td>8.53</td>
</tr>
</tbody>
</table>

Source OECD: [http://dx.doi.org/10.1787/826773162617](http://dx.doi.org/10.1787/826773162617)
2.2 Forecasting
Logs and Growth Rates

Let $y_t$ be real GDP at time $t$; $\Delta y_t$ we denote growth of $y_t$

$$\Delta y_{t+1} = \frac{y_{t+1} - y_t}{y_t}$$

$$\Delta y_{t+1} = \frac{y_{t+1}}{y_t} - 1$$

$$\log (1 + \Delta y_{t+1}) = \log(y_{t+1}) - \log(y_t)$$

Note $\log(1 + x) \approx x$ if $x$ is small ... so

$$\Delta y_{t+1} \approx \log(y_{t+1}) - \log(y_t)$$

- Plotting log of GDP is much easier to identify growth rates.
- In a log GDP plot, the slope determines the growth rate.

U.S. GDP Over Time

Log of U.S. real GDP (in 2000 dollars) 1900 - 2013

The graph above implies a constant growth rate (approx. 2%)
The result holds going back to 1790.

The result holds looking in per-capita terms.

Check for yourself here:
http://www.measuringworth.com/datasets/usgdp12/

Can we use this robust “trend” of U.S GDP to predict future values?

Forecasting: Introduction

This Lecture:
1. Trend forecasting;
2. Single time series forecasting.

Later In the Course:
1. Multiple time series forecasting.
Forecasting: Basic Definitions

Definition (Time Series)

A time series is a sequence of values recorded at (usually) equidistant time intervals. We denote with \( \{x_n\}_{n=1}^t \) a time series containing \( t \) values.

- Loosely: a forecast of a time series \( x_t \) is a guess about future values of it: for example what will GDP be on Apr 30, 2014.

- To formally build a forecast we need to specify:
  1. What information we have available for the forecast;
  2. What are the cost involved in a wrong forecast!

Forecasting: Information Sets

Definition (Information Sets)

Let \( I_t \) be the set of information available at time \( t \) for a forecast.

- The information set \( I_t \) we will use can be of two types:
  1. \( I_t = \{x_n\}_{n=1}^{t-1} \): for the forecast we have available only past values of the time series we want to forecast. This will be the case in this lecture.
  2. \( I_t = \{x_n\}_{n=1}^{t-1} \cup \{c_n\}_{n=1}^{t-1} \): for the forecast we have available past values of the time series we want to forecast and of another time series \( c_t \). We will talk about this later in the course.
Definition (Forecast Errors)

Suppose that at time $t$ we have forecasted the future value: $x_{t+1}$. At time $t+1$ we observe the real value: $\hat{x}_{t+1}$. Our error is:

$$e_{t+1} = \hat{x}_{t+1} - x_{t+1}.$$

- Not all types of errors are the same....
- For example, suppose you are forecasting future demand of a product. Over-estimating demand will imply a cost due to unsold items. Under-estimating demand will imply an opportunity cost for lost business.

Forecasting: Penalty Functions

- Let $C(e)$ be the penalty function associated with error $e$.
- A good forecast is one that minimizes the overall penalty function.
- A common approach is to use the square of the error $\Rightarrow C(e) = e^2$.
- In this class we will do a hands-on approach. For a formal treatment refer to your econometrics and statistics classes.

Fitting a Linear Trend

- An idea motivated by the above: if log GDP has grown linearly, is it natural to think it will continue to do so?
• An experiment: suppose I was teaching this class on Jan 22, 1960. Suppose I wanted to figure out what GDP would be on Jan 22, 2014, how would I proceed?

• In this experiment we only use past real GDP information from 1947 to 1960:

\[ I_{1960} = \{ \hat{y}_n \}_{n=1947}^{1959} \]

where \( \hat{y}_t \) is GDP in year \( t \).

• We will minimize the square of the error so that:

\[ C(e_{2014}) = (\hat{x}_{2014} - x_{2014})^2 \]

where \( x_{2014} \) is our forecast of GDP for 2014.

Fitting a Trend

• Excel provides several function to add a linear trend-line.

• SLOPE(known y’s,known x’s)
  Returns the slope of the linear regression line through data points in known y’s (values) and known x’s (dates).

• INTERCEPT(known y’s,known x’s)
  The intercept point is based on a best-fit regression line plotted through the known y’s (values) and known x’s (dates).

Refer to your econometrics and regression analysis class for precise formulas.

Back to the 1960s: Part 1

Algorithm used to find the linear trend forecast:

1. I use Nominal GDP from NIPA Table 1.1.5
3. I take logs (natural logarithm) of the series.
4. Use SLOPE and INTERCEPT to find a linear trend.
5. Extend the linear trend to Jan 22, 2014.
The forecast is remarkably close to actual data!

The forecast is under-estimating actual GDP by 15%

Trend seems to increase in the 70s and decrease in the 90s.

Deviations from trend

Definition (Deviation From Trend)

Let \( \hat{x}_t \) the actual values of a time series. Let \( x_t \) be the values of the fitted trend line. Define the deviation from trend as \( d_t = \hat{x}_t - x_t \).

From our previous experiment:

The deviations from trend don’t appear completely random, there seems to be a degree of “correlation” over time.

Forecasting: Time Series

A question. How confident are we about our forecast?

A model for \( d_t \) can help provide an answer.

What model should we have for \( d_t \)? From the previous picture it seems there is a persistence component and a “shock” component.

\[
    d_t = \alpha d_{t-1} + \varepsilon_t
\]

\( d_t \) is an auto-regressive process:

1. \( \alpha \in [0, 1] \) denotes the persistence of the process.
2. \( \varepsilon_t \) is a shock process with variance \( \sigma^2 \).
Appendix: Autoregressive Processes

• Given an autoregressive process:
  \[ d_t = \alpha d_{t-1} + \varepsilon_t \]

• We have that:
  \[ \alpha = \frac{\text{cov}(d_t, d_{t-1})}{\text{var}(d_t)}. \]

• The variance of \( \varepsilon_t \) can be computed directly.
  \[ \sigma^2 = \text{var}(d_t - \alpha d_{t-1}). \]

Q: Why do we care? Knowing \( \sigma^2 \) provides confidence intervals around our original estimate.

Appendix: Autoregressive Processes

• Suppose we are performing a forecast \( k \) period ahead.

• Given an estimate of \( \alpha \) and \( \sigma^2 \) let
  \[ \delta^2_k = \begin{cases} 
  k\sigma^2 & \text{if } \alpha = 1 \\
  \frac{1-\alpha^2k}{1-\alpha^2} \sigma^2 & \text{if } \alpha < 1 
\end{cases} \]

• The 95% confidence intervals are given by:
  \[ x_{t+k} \pm 2\sqrt{\delta^2_k} \]
  where \( x_{t+k} \) is our trend forecast \( k \) periods ahead.

• The idea is that the more variable a time series is, the least certain we can be about a forecast.

Back to the 1960s: Part 2

Algorithm used to find the confidence intervals:

1. Calculated the deviations from trend: \( d_t \).
2. Compute \( \alpha \) using the function CORREL in Excel.
3. Compute \( \varepsilon_t = d_t - \alpha d_{t-1} \).
4. Compute the variance of \( \varepsilon_t \) using function VAR in Excel.
5. Compute \( \delta^2_k \).
6. Compute the upper bound: \( x_{t+k} + 2\sqrt{\delta^2_k} \) and lower bound: \( x_{t+k} - 2\sqrt{\delta^2_k} \).
• Actual data is within the 95% confidence bands.
2.3 Trend and Cycles
Definitions:

**Recession**
- Two consecutive quarters of decline in real GDP.
- *NBER:* A significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales.

**Depression**
- Large output drop > 10% lasting several years

For more information visit here: [http://www.nber.org/cycles.html](http://www.nber.org/cycles.html)

---

### Trend and Cycle

- In the previous experiment the fitted trend line was used to perform forecast about the future.
- The fitted trend line is also useful to study separately aspects concerning **long term growth** and **short term fluctuations**.
- Economist usually study (so will we in class) separately.

---

**Trend:** captures the long term growth rate of the economy.

**Cycle:** captures short lived deviation from the trend.
Deviations from trend

Definition (Deviation From Trend)
Let $\hat{x}_t$ the actual values of a time series. Let $x_t$ be the values of the fitted trend line. Define the deviation from trend as $d_t = \hat{x}_t - x_t$.

From our previous experiment:

- We observe both Large secular fluctuations: “productivity slowdowns”. and Smaller fluctuations: “business cycles”.

Non-Linear Trend

- The previous plot shows that a linear trend misses the fast growth of the 70s and the slowdown in the 90s.
- This is an artifice of the simple nature of the trend used: a line.
- We now use a more flexible trend (also called a non-linear filter).
- The once considered is the Hodrick-Prescott (HP) filter.

The Hodrick-Prescott filter

Let $y_t$ be GDP in year $t$. Suppose you have data for $T$ years. Suppose that:

$$y_t = \varepsilon_t + x_t$$

Cyclical component  Trend component

The HP filter finds the trend solving the following problem

$$\min_{\{g_t\}_{t=1}^T} \left\{ \sum_{t=1}^T (y_t - x_t)^2 + \lambda \sum_{t=2}^{T-1} [(x_{t+1} - x_t) - (x_t - x_{t-1})]^2 \right\}$$

$\lambda$ is called the smoothing parameter

- Set $\lambda = 100$ if GDP is in yearly data
- Set $\lambda = 1600$ if GDP is in quarterly data
- Observe the slow moving trend line.

### HP Filter and U.S. GDP

- Given the trend line is straightforward to compute deviations from trend.

### The Cyclical Component

What to do when we derive the cyclical component?

- We can study the **frequency** of the fluctuations.
- We can study the **amplitude** of the fluctuations.
- More important, the cyclical component of GDP can serve as a benchmark for other macroeconomic quantities.
Two Time Variables: How to study them?

Let $x_t$ and $y_t$ be two time variables (for example: GDP, Inflation).
Natural questions you might ask:

- Are the two variable “related”?
- Is one variable “predicting” the other?
- Does one variable “move” more than the other?

Two Time Variables: Correlation

Remember correlation does not imply causation!!!

When the trend is removed from the two variables economist usually talk about co-movement rather than correlation

Q: If I have two variables that grow at the same rate and do not remove the trend what will be the correlation?
Two Time Variables: Correlation

**Definition**

A macroeconomic variable is:

- **Pro-cyclical**: if deviations from trend are positively correlated with deviations from trend of real GDP.
- **Counter-cyclical**: if deviations from trend are negatively correlated with deviation from trend of real GDP.
- **A-cyclical**: if deviations from trend are not correlated.

Two Time Variables: Lead and Lag

If \( x_t \) and \( y_t \) are positively correlated, additional information on comovement

![Graph](image)

Two Time Variables: Amplitude

- Is also important also to look at the amplitude of deviation from trend of the two variables (who fluctuates more?)

To summarize, with two economic variables you should remember:

1. How they are correlated? pro-cyclical, countercyclical
2. How they are synchronized? lead-lag
3. How do the fluctuations compare? amplitude
Deviation From Trend Consumption vs. GDP

- Consumption is: pro-cyclical, coincident and slightly less variable

Deviation From Trend Investment vs. GDP

- Investment is: pro-cyclical, coincident and more variable
• Employment level is pro-cyclical, lagging and less variable

Relation Between Variables: Summary

<table>
<thead>
<tr>
<th>Table 3.1</th>
<th>Correlation Coefficients and Variability of Percentage Deviations from Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation Coefficient</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.76</td>
</tr>
<tr>
<td>Investment</td>
<td>0.84</td>
</tr>
<tr>
<td>Price Level</td>
<td>−0.23</td>
</tr>
<tr>
<td>Money Supply</td>
<td>0.26</td>
</tr>
<tr>
<td>Employment</td>
<td>0.80</td>
</tr>
<tr>
<td>Average Labor Productivity</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Relation Between Variables: Summary

• Goal for the semester: construct a theory to explain these facts!
• Also, can the theory guide us to “better forecasts”?
2.4 Nominal and Real GDP
Plan For This Lecture

1. Nominal and Real GDP.
   - http://www.youtube.com/watch?v=jTmXHvGZiSY

2. Study Price levels: CPI and GDP deflator.

Real and Nominal Quantities

Some definitions:

- A nominal quantity: is a dollar denominated quantity, denoting the market value of a quantity with prices defined at the time of production.

- A real quantity: is a dollar denominated quantity, denoting the market value of a quantity with prices defined in a given year.

- A price level: is a weighted average of prices at a given time.

- A price index: is the ratio of two price levels.

A 2 x 2 Economy

Example economy lasts for 2 periods: 2013 - 2014; 2 goods are produced: Apples and Oranges. The data:

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Oranges</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>Prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apples</td>
<td>1.2 $</td>
<td>0.6 $</td>
</tr>
<tr>
<td>Oranges</td>
<td>0.2 $</td>
<td>0.24 $</td>
</tr>
<tr>
<td>Values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apples</td>
<td>6 $</td>
<td>6 $</td>
</tr>
<tr>
<td>Oranges</td>
<td>40 $</td>
<td>60 $</td>
</tr>
<tr>
<td>Nominal GDP</td>
<td>46 $</td>
<td>66 $</td>
</tr>
</tbody>
</table>

Quantities and prices are changing, is nominal GDP informative? No. Real GDP will provide a measure about real changes!
• Once we define a price index we can move between the two quantities:

\[ \text{Real GDP} = \frac{\text{Nominal GDP}}{\text{Price Index}} \]

• To define a price index we need to determine a base year. A year for which the price index is normalized to 1.

\[ \text{Price Index}(t) = \frac{\text{Price level}(t)}{\text{Price level(base year)}} \]

---

Keeping Prices Fixed

• Steps to convert Nominal GDP to Real GDP:
  1. Determine a base year.
  2. Construct a price level; we have two options:
     - Fix weights for prices using quantities in the base year. This is called the Base-weighted or Laspeyres approach.
     - Every period change weights for prices using current quantities. This is called the Current-weighted or Paasche approach.
  3. Construct the price index.
  4. Divide the time series of Nominal GDP by the constructed price index.

Laspeyres vs Paasche

Let \( P_t^i \) = prices, \( X_t^i \) = quantities of good \( i \) at time \( t \). Nominal GDP is:

\[ \text{GDP}(t) = \sum_{i=1}^{N} P_t^i X_t^i \]

• Let \( t_0 \) be the base year. The Laspeyres index for year time \( t \) is:

\[ P^{\text{Laspeyres}}(t) = \frac{\sum_{i=1}^{N} P_t^i X_t^{i_0}}{\sum_{i=1}^{N} P_{t_0}^i X_t^{i_0}} \]

• Let \( t_0 \) be the base year. The Paasche index for year \( t \) is:

\[ P^{\text{Paasche}}(t) = \frac{\sum_{i=1}^{N} P_t^i X_t^i}{\sum_{i=1}^{N} P_{t_0}^i X_t^i} \]
The Laspeyres Index

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013 Base year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Oranges</td>
<td>200</td>
<td>250</td>
</tr>
</tbody>
</table>

**Prices**

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013 Base year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>1.2 $</td>
<td>0.6 $</td>
</tr>
<tr>
<td>Oranges</td>
<td>0.2 $</td>
<td>0.24 $</td>
</tr>
</tbody>
</table>

**Values**

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013 Base year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>6 $</td>
<td>3 $</td>
</tr>
<tr>
<td>Oranges</td>
<td>40 $</td>
<td>48 $</td>
</tr>
</tbody>
</table>

**Laspeyres Index**

\[
\text{Laspeyres Index} = \frac{6\,\text{$/10} + 48\,\text{$/40}}{6\,\text{$/10} + 48\,\text{$/40}} = \frac{51\,\text{$/50}}{46\,\text{$/50}} = 1.11
\]

- To calculate price index in 2014 use quantities of 2013.
- Price Index increases by 11% between 2013 and 2014.

The Paasche Index

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013 Base year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>5/10</td>
<td>10</td>
</tr>
<tr>
<td>Oranges</td>
<td>250</td>
<td>250</td>
</tr>
</tbody>
</table>

**Prices**

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013 Base year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>1.2 $</td>
<td>0.6 $</td>
</tr>
<tr>
<td>Oranges</td>
<td>0.2 $</td>
<td>0.24 $</td>
</tr>
</tbody>
</table>

**Values**

<table>
<thead>
<tr>
<th>Product/Time</th>
<th>2013 Base year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>12 $</td>
<td>6 $</td>
</tr>
<tr>
<td>Oranges</td>
<td>50 $</td>
<td>60 $</td>
</tr>
</tbody>
</table>

**Paasche Index**

\[
\text{Paasche Index} = \frac{6\,\text{$/10} + 60\,\text{$/50}}{12\,\text{$/10} + 60\,\text{$/50}} = \frac{66\,\text{$/62}}{62\,\text{$/62}} = 1.064
\]

- To calculate price index in 2014 use quantities of 2014.
- Price Index increases by 6.4% between 2013 and 2014.

Nominal and Real GDP Growth

Recall:

\[
\text{Real GDP} = \frac{\text{Nominal GDP}}{\text{Price Index}}
\]

<table>
<thead>
<tr>
<th>Variable ($)</th>
<th>2013</th>
<th>2014</th>
<th>Growth $\Delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal GDP</td>
<td>46</td>
<td>66</td>
<td>43.5%</td>
</tr>
<tr>
<td>Real GDP - Laspeyres</td>
<td>46/1 = 46</td>
<td>66/1.11</td>
<td>29.26%</td>
</tr>
<tr>
<td>Real GDP - Paasche</td>
<td>46/1 = 46</td>
<td>66/1.064</td>
<td>34.86%</td>
</tr>
</tbody>
</table>

- Two measures of Real GDP growth differ!
- In the US we use two different price indexes:
  1. GDP deflator
  2. CPI (consumption price index)
Nominal and Real GDP using GDP Deflator

Question: what happens in 2009?

GDP Deflator Vs. CPI: Comparing 2014 vs 2009

- **Deflator**
  
  Key feature 1: keep quantities fixed at the current year
  
  Key feature 2: every good and service enters in the price index

- **CPI**
  
  Key feature 1: keep quantities fixed at base year (2009)
  
  Key feature 2: only quantities purchased by consumers (C)

\[
\text{CPI}(2014) = \frac{\sum_{i \in C} P_{i}^{2014} X_{i}^{2009}}{\sum_{i \in C} P_{i}^{2009} X_{i}^{2009}}
\]

GDP Deflator vs. CPI

The two quantities differ over time!
Inflation

Inflation (i): the % change in the GDP deflator between two consecutive years. For example:

\[ i_{2014} = \frac{Deflator_{2014} - Deflator_{2013}}{Deflator_{2013}} \times 100 \]

- Inflation-CPI determines changes in the cost of living (constructed using CPI rather than GDP deflator)
- Question: If you were a worker in 1970, you would like your contract to be indexed to which value of inflation?

Inflation in the US

- Inflation is rarely negative.
- Period of high inflation in the 70s.

Putting Things in Perspective

Zimbabwe 2008: How about 231,000,000% Inflation?
Chapter 3

The Household
How many new jobs/hires are there each month?


---

Plan for This Lecture

1. The Household
   - Data
   - The utility function
   - Indifference Curves

2. Household constraints

3. Households optimization
   - Income and Substitution effects

4. Aggregation

---

The Household

Who are the “households” in the US economy?

- In our model a households will be a unit working and consuming. To whom should we model after?

- From US Census: population clock as of Jan 28 2014: 317,441,572
  (http://www.census.gov/main/www/popclock.html)

- From BLS: Number of consumer units (2012): 124,416,000
  (http://www.bls.gov/news.release/cesan.nr0.htm)
The Average Household: Working

- From BLS: Civilian labor force: 154,408,000
  Unemployed (Dec 2013): 9,984,000
  (http://www.bls.gov/news.release/empsit.t01.htm)

- Average hours worked per week (2013): 34.4
  Average hourly earnings: $24.17 (2013)
  (http://www.bls.gov/news.release/empsit.b.htm)

The Average Household: Not Working

What about unemployment rate ($U$)?

\[
U = \frac{\text{labor force} - \text{employment}}{\text{labor force}} \cdot 100 = \frac{\text{unemployed}}{\text{labor force}} \cdot 100
\]

Using previous data

\[
U = \frac{9,984,000}{154,408,000} \cdot 100 \approx 6.46\%
\]

- Note in this part of the course we will not model unemployment. Instead we will focus in changes of average hours worked.

The Average Household: Consuming

1. Excellent source: consumer expenditure survey
   http://www.bls.gov/cex/

   Some spending categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>$6,532</td>
</tr>
<tr>
<td>Housing</td>
<td>$16,940</td>
</tr>
<tr>
<td>Transportation</td>
<td>$8,505</td>
</tr>
<tr>
<td>Healthcare</td>
<td>$3,466</td>
</tr>
</tbody>
</table>
The Household

• The Household (a.k.a the representative consumer), cares about:
  1. Consumption: $c$
  2. Leisure: $l$

(Note, in GDP consumption is $C$ here is $c$... it is not a typo, check the end of the lecture!)

• The household (HH) has a goal: be happy.

The Household: Assumptions

We assume that:

1. All the households have the same tastes
2. Households are very smart! (understand how the world works and can solve max)
3. Households are not jealous, do not have regrets...
4. For the next month: households live one period (we do not have to worry about savings just yet)

About Assumptions

• Are these good or bad assumptions?

• To answer this question we follow the paper by Friedman “The Methodology of Positive Economics” (On blackboard)
  - Do not evaluate assumption by realistic appeal (Think about Newton modeling apple falling in a vacuum)
  - Evaluate assumption by ability to replicate data (Think about Newton prediction of flight-time of the apple falling)
The Decision of The Household

The household (HH) has a goal: be happy

- The utility function $U$ represents the happiness of the HH:
  - **For every bundle** $(c,l)$, $U(c,l)$ associates a level of utility
  - **We say that** $(c_1,l_1)$ is preferred to $(c_2,l_2)$ if and only if
    \[ U(c_1,l_1) > U(c_2,l_2) \]

- The objective of the HH is to maximize $U(c,l)$ on every pair $(c,l)$ that it has available (feasible and affordable)

---

Some Math Notes

- A function $f(x)$ is a relation that uniquely associates members of one set with members of another set.

- A derivative of function $f(x)$, denoted $f'(x)$ is a function that at every point $x$ associates the slope of $f$.
  \[
  \frac{df(x)}{dx} \equiv f'(x) = \lim_{\Delta x \to 0} \frac{f(x + \Delta x) - f(x)}{\Delta x}
  \]
  Note: $\frac{d^2 f(x)}{dx^2} \equiv \frac{d f'(x)}{dx}$

---

Properties of the Utility Function

Properties of the utility function:

1. **Utility is increasing** (more is preferred to less)
   \[
   \frac{dU(c,l)}{dc} > 0; \quad \frac{dU(c,l)}{dl} > 0
   \]

2. **Concavity**: each additional unit of consumption and leisure adds less utility
   (eating twice as much does not make you twice as happy)
   \[
   \frac{d^2U(c,l)}{dc^2} < 0; \quad \frac{d^2U(c,l)}{dl^2} < 0
   \]

Important Implication: Households do not like risk.
• We look at 2 dimensional utility functions (HH cares about \( c \) AND \( l \))

• How can we summarize preference? using indifference curves

**Definition (indifference curve)**

An Indifference curve is a curve connecting all values of consumption and leisure among which the consumer is indifferent.

---

**Indifference Curves**

• Utility is increasing \( \Rightarrow \) Indifference curves are downward sloping

• HH like diversity \( \Rightarrow \) Indifference curves are convex

---

**Household Constraints**
HH Constraints

In our economic model, HH have

- **Limited amount of time** available: let $N_s$ be time working

\[ l + N_s = 24 \text{ hours} = h \]

In the data what else we know about usage of time?

- Usage of time for American residents: [http://tinyurl.com/usage-time](http://tinyurl.com/usage-time)

The Budget Constraint

- **Limited disposable income**: a budget constraint

Let:

- $c =$ consumption
- $h =$ time endowment
- $l =$ leisure time
- $w =$ hourly wage
- $\pi =$ dividend income
- $T =$ lump sum taxes (rebates)

\[ c = w(h - l) + \pi - T \]

Question: How would you write an income tax?
If $T < 0$ we call it a Transfer to the household. In the US the following are the biggest source of transfers to the Households:

- Food Stamps:

- Unemployment Insurance:

- Disability Insurance:

- Temporary assistance for needy families (TANF):

### Unemployment Insurance

- Claims for unemployment insurance is a leading indicator:

![Unemployment Insurance Claims](image)

### The Budget Constraint

- Wages determines the slope of the budget constraint.
- $\pi$ and $T$ determine the intercept.
• Suppose now $T < \pi$: positive consumption even with no work

**Consumer Maximization**

A consumption-leisure bundle is:

• **Affordable** if it lies on or within the budget set.

• **Optimal** if it is affordable and is on the highest indifference curve.
Only $H$ is optimal!!

**Consumer Maximization: Math!**

The household problem:

$$\max_{c,l} U(c, l)$$

subject to

$$w(h - l) + \pi - T = c$$

Write the lagrangian:

$$\mathcal{L}(c, l, \lambda) = U(c, l) + \lambda[w(h - l) + \pi - T - c]$$

where $\lambda$ is our lagrange multiplier. First order conditions

(C) : $U_c(c, l) - \lambda = 0$

(l) : $U_l(c, l) - w\lambda = 0$

(\lambda) : $w(h - l) + \pi - T - c = 0$

**Consumer Maximization: More Math!**

Let’s substitute out $\lambda$ from the two first order conditions:

$$U_l(c, l) - w \cdot U_c(c, l) = 0$$

$$\frac{U_l(c, l)}{U_c(c, l)} = w$$

And what is $\frac{U_l(c, l)}{U_c(c, l)}$?

$$\Rightarrow \frac{U_l(c, l)}{U_c(c, l)} = MRS_{l,c} = w$$
The Marginal Rate of Substitution

Definition (Marginal Rate of Substitution)
The **marginal rate of substitution** is the rate at which a consumer is willing to give up one good in exchange for another good while maintaining the same level of utility.

- A consumption-leisure bundle is optimal when:
  - Is on the budget line (Walras law)
  - Slope of indifference curve = Slope of budget line

Which implies $\frac{MRS_{l,c}}{w} = 1$

Choosing Unemployment

- Be careful with corner solutions!!

Income and Substitution Effects
Effect of changing parameters of the model (comparative static) can be decomposed in:

**Definition**

- **Income Effect:**
  The effect on quantities as a result of having **different income** holding prices constant.

- **Substitution Effect:**
  The effect on quantities given a price change holding utility constant.

---

**Income and Substitution Effects: Example**

- **Pure Income Effect:** winning the lottery
- **Pure Substitution Effect:** high wage only for 1 day
- **Income + Substitution Effect:** permanent high wage

---

**Income and Substitution Effects: Example**

- **Pure Income Effect:** winning the lottery → more leisure.
- **Pure Substitution Effect:** high wage only for 1 day → less leisure.
- **Income + Substitution Effect:** permanent high wage → leisure?
Income and Substitution Effects

- **Income Effect**: more income → more leisure.
- **Substitution Effect**: higher wage → less leisure.

Note:
1. A higher wage (lower income tax) induces both an income and substitution effect.
2. The overall effect is undetermined, we must proceed quantitatively.

---

**Comparative Static: Changing \( \pi - T \)**

- Suppose \( \pi \) increases or \( T \) decreases.
- Since \( c \) and \( l \) are normal goods → the richer you are the more you want

---

**Comparative Static: Changing Wages**

- Suppose your wage goes up.
- Remember: leisure is more expensive
- In general this case features both income and substitution effects → leisure changes are undetermined.
• So far we have studied problem of a single household.
• We need to compare aggregate quantities (GDP, C,...) and household decision (called $c_i$ and $l_i$ in this slide).
• In Macro Economics the problem of going from one to many household is referred to as an: aggregation problem.

The Issue:
1. In the data we have household with disparate income levels.
2. In the data we have household with different tastes.

The Solution: Assumptions

**Definition (Homogeneous of Degree One)**

Homogeneous function of degree 1: if for all $n \in \mathbb{R}$:

$$n \cdot f(x) = f(n \cdot x)$$

• Key assumptions:
  1. Utility function is homogeneous of degree one.
  2. Households have similar preferences.

Aggregation

We have:

$$\sum_{i=1}^{N} \max_{c_i, l_i} u_i(c_i, l_i) \Rightarrow N \max_{c, l} u(c, l) \Rightarrow \max_{c, l} u\left(\frac{N}{C} \cdot c, \frac{N}{L} \cdot l\right)$$

• $C = N \cdot c$: aggregate consumption;
• $L = N \cdot l$: aggregate leisure.
Q: How good is the assumption that $c_i$ is the same for everybody? (I.e. how good is assumption about homogeneity?)

A: Not too bad..
Check your micro lectures for the notion of homotheticity/homogeneity.
Chapter 4

The Firm
Suppose 10% of U.S. capital stock gets destroyed. How much will GDP decrease by?

Your answer here: http://tinyurl.com/73240-ales

Plan for this Lecture

1. The Firm
   - Data: firms in the US
   - The representative firm
   - The production function

2. Firm maximization
   - Calibrating the capital share: $\alpha$

Note: with this lecture we finish Ch.4 - Review it!!

U.S. Firms: Data

How many businesses?

- **Non-employers** (firms with no payroll): 21,708,021 (census data 2008)
- **Employers** (firms with payroll): (census data 2008)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Firms</td>
<td>6,022,127</td>
</tr>
<tr>
<td>Establishments</td>
<td>7,601,160</td>
</tr>
<tr>
<td>Employment</td>
<td>119,917,165</td>
</tr>
</tbody>
</table>

Source: http://www.census.gov/epcd/www/smallbus.html
What is the distribution of firm size?

![Graph showing the probability distribution function (PDF) of U.S. firm sizes, 1997 Economic Census data.](source: Robert Axtell)

- Look on the web for **Zipf law**!
- A firm over time: [LINK](#)

### U.S. Firms: Data

- Source: [http://www.bea.gov/industry/](http://www.bea.gov/industry/)
- Look at behavior of Professional vs Manufacturing.

---

**The Representative Firm**

**And**

**The Production Function**
The Firm

- A firm converts inputs (factors of productions) into output (consumption goods)

- Goal of the firm: maximize profits

Assumptions:
1. Firms are very smart
2. They all have similar technology \( \rightarrow \) exists a representative firm
3. They use only two factors of productions: capital and labor
4. Live 1 period (relaxed later in the course)
5. No financing issues (relaxed later in the course)

The Production Function

Let:
- Capital: \( K \)
- Labor employed: \( N^d \)
- Total Factor Productivity (TFP): \( z \)
- Output: \( Y \)

Ability of a firm to transform factors of production into output is summarized by the production function \( F \)

\[ Y = zF(K, N^d) \]

Properties of the Production Function

1. \( F \) is increasing
   \[ \frac{dF(K, N)}{dK} > 0 \quad \frac{dF(K, N)}{dN} > 0 \]

2. \( F \) exhibits constant return to scale
   “Double the size double the output”
   \[ zF(xK, xN^d) = xzF(K, N^d) \]

Note: This –as for the consumer– is key to study a representative firm

Note: decreasing (increasing) returns to scale

\[ zF(xK, xN^d) < (>) xzF(K, N^d) \]
Marginal Products

- Marginal product of capital (labor) \( MP_K (MP_N) \) is the additional output produced by increasing capital (labor) by one unit, keeping fixed the other input.

\[
\begin{align*}
\text{Marginal Product of Capital (Labor)}
\end{align*}
\]

Properties of the Production Function

Note: \( MP_K = z \frac{dF}{dK} \) and \( MP_N = z \frac{dF}{dN} \)

- \( F \) is concave:
  - \( MP_N \) decreases as \( N \) increases (alternatively \( \frac{\partial^2 F}{\partial N^2} < 0 \))
  - \( MP_K \) decreases as \( K \) increases (alternatively \( \frac{\partial^2 F}{\partial K^2} < 0 \))

(Example: double the size of a study group)

- \( MP_N \) increases as capital increases:

(Example: buy a laptop for a student)

Example: TFP Shock

- Consider two economies 1 and 2 with \( z_2 > z_1 \)

Why do we care? Think how wages change with technology
The Production Function

Very popular production function is the **Cobb-Douglas**

\[ Y = zK^\alpha (N^d)^{(1-\alpha)} \]

With \( 0 < \alpha < 1 \) (\( \alpha \) = capital share). Examples:

- Kenya vs. U.S.
  
  \[ z_{\text{Kenya}} < z_{\text{U.S.}} \]

  
  \[ z_{1776} < z_{2014} \]
  \[ K_{1776} < K_{2014} \]

Question: what are \( \alpha \) and \( z \) for the U.S. today?

---

**Firm Maximization**

The Problem of the Firm

Some additional assumption:

1. The objective of a firm is to maximize profits.
2. A firm owns the capital
   (later we will introduce the investment decision.)
3. Firms takes the wage as given from the market.
4. No taxes in the baseline environment.
5. The firm sets the demand for labor: \( N^d \).
Let:

Revenue: \( zF(K, N^d) \)

Variable cost: \( wN^d \)

**Profits** = \( \pi = zF(K, N^d) - wN^d \)

The firm solves:

\[
\max_{N^d} zF(K, N^d) - wN^d
\]

Question: Why doesn’t the firm choose \( N^d \) VERY large?

---

**Optimal Labor Choice**

Choose \( N^d \) so that: \( MP_N = w \)

---

**Solution: Intuition**

Suppose \( MP_N > w \)

- Then raise \( N^d \) very little: revenue raise faster than the costs

Suppose \( MP_N < w \)

- Then lower \( N^d \) very little: revenue decrease slower than the costs

In both cases we reach a contradiction so that the only alternative is:

\( MP_N = w \)
What is $\alpha$?

Solution: Example

Useful property of a Cobb-Douglas production function:

$$MP_N = z(1 - \alpha)K^\alpha N^{1-\alpha}N^{-1}$$

$$= (1 - \alpha)zK^\alpha N^{1-\alpha}N^{-1}$$

$$MP_N = (1 - \alpha)\frac{Y}{N}$$

We can relate $MP_N$ to output per worker $N/Y$.

The Labor Share of Income

We now calculate $\alpha$ from the data. Start from previous equation:

$$MP_N = w = (1 - \alpha)\frac{Y}{N}$$

Solve for $1 - \alpha$:

$$1 - \alpha = \frac{wN}{Y}$$

Where:

1. $wN$ is the compensation of employees
2. $Y$ is GDP

Both can be obtained from the data!
Calculating The Labor Share From Data

Remember the three ways to calculate $Y$?

Let’s compute $\alpha$ from the BEA data: Table 2.1

Changes in Capital Stock and $\alpha$

- At the beginning of class I asked you about the effect of a 10% decrease in the U.S. capital stock. The number provided is connected with $\alpha$.
- From Lecture 3 we have that:
  \[ \text{Growth Rate of } Y_t = \log(Y_{t+1}) - \log(Y_t) \]
- In our example:
  \[ \log(Y_t) = z_t + \alpha \log(K_t) + (1 - \alpha) \log N_t \]
  
  So that (if $N_t$ and $z_t$ do not change)
  \[ \text{Growth Rate of } Y_t = \frac{\log(Y_{t+1}) - \log(Y_t)}{10\%} = \alpha \cdot \text{Growth Rate of } K_t \]

Labor Demand
U.S. Firm Data: Employment

Source: http://www.bls.gov/web/cewbd/

Who Affects Un-Employment?

Source: http://www.bls.gov/web/cewbd/

Note how the recession unemployment due to contractions rather than failures.

Solution of the Firm Problem

Consider $F(K, N) = K^\alpha N^{1-\alpha}$ (notice: I removed the superscript $D$)

The firm solves:

$$\max_N \pi(N) = \max_N zK^\alpha N^{1-\alpha} - wN$$

To solve, take first order condition:

$$\frac{d\pi}{dN} = z(1 - \alpha)K^\alpha N^{-\alpha} - w = 0$$

Our optimality condition:

$$z(1 - \alpha) \left( \frac{K}{N} \right)^\alpha = w$$

Source: U.S. Bureau of Labor Statistics

Note: Shaded area represents NBER defined recession period.
The firm problem provides the key equation that determines the demand for labor:

\[ N = \left[ \frac{z(1 - \alpha)K^\alpha}{w} \right]^{\frac{1}{\alpha}} \]

**Comparative statics:**

1. \( z \) increases \( \rightarrow \) \( N \) increases
2. \( K \) increases \( \rightarrow \) \( N \) increases
3. \( w \) increases \( \rightarrow \) \( N \) decreases

---

**Labor Demand: Exercise**

- Labor Demand:

\[ N = \left[ \frac{z(1 - \alpha)K^\alpha}{w} \right]^{\frac{1}{\alpha}} \]

- Suppose \( K \) changes by 1%.

1. By how much should we expect \( N \) to change?
2. What key assumption are we making?

- Proceeding as before:

\[ \log N_t = \frac{1}{\alpha} \left[ \log z_t - \log w_t + \log(1 - \alpha) + \alpha \log K_t \right] \]

- Assume \( w_t \) does not change.

- The growth rate of \( N \) depends 1:1 with growth rate of \( K \).

---

**Firm Problem: Other Examples**

We can now study what happens if:

2. Government subsidizes employment.
3. Firm have a minimum firm size \( \bar{N} \).

Note these are partial equilibrium examples. What are we missing?
Chapter 5

The Government
The Government

The Government: Size

- Employed (2012) ⇒ Federal + State and Local: 21,973,000
  http://research.stlouisfed.org/fred2/series/USGOVT

- Government expenditures:

Governments Size Across Countries

Source: OECD
In our model the government is benevolent:

- maximizes welfare of its citizen

Question: why do we need a government?

It provides public goods:

- Schools, Police, Fire, Military
- Infrastructures

It corrects market failures:

- SEC, FTC, Retirement (?), CO₂

---

The Government: Budget Constraint

Let $G$ be the dollar value of the public goods. In a static world the budget constraint is:

$$ G = T $$

When we will look at dynamics we will have

$$ G = T + Δ\text{debt} $$

---

Governments in Europe: Debt size

In 2012:
### The Government: Data

#### Policy Outlays by Category

2011

- **Security Discretionary**
- **Non-Security Discretionary**
- **Social Security**
- **Medicare**
- **Medicaid**
- **Net Interest**
- **Other Mandatory Programs and Disaster Costs**

Source: U.S budget 2011

- Current Budget: [LINK](#)
- Historical data: [LINK](#)

Slide 9 of 41

#### The Government: Budget Constraint

- Static government budget constraint is:
  \[
  G = T
  \]

- Taxes \(T\) also appear in the household budget constraint:
  \[
  C = wN + \pi - T
  \]

- In the data from where does the government draws revenue?

Slide 10 of 41

#### The Government: Data

#### Policy Revenues by Source

2011

- **Individual Income Taxes**
- **Corporation Income Taxes**
- **Unemployment Insurance**
- **Medicare Payroll Taxes**
- **Social Security Payroll Taxes**
- **Excise Taxes**
- **Other Receipts**
- **Borrowing and Other Net Financing**

Source: U.S budget 2011

Slide 11 of 41
The impact of Government policy on HH and Firm:

- $\tau_y$: income tax (appears in HH budget constraint)
  \[ C = (1 - \tau_y)wN^s + \pi - T \]
- $\tau_c$: tax on consumption (appears in HH budget constraint)
  \[ (1 + \tau_c)C = wN^s + \pi - T \]
- $\tau_r$: tax on revenues (appears in firm profits)
  \[ Y = (1 - \tau_r)zF(k, N^d) - wN^d \]

Who Pays Income Tax?

Chapter 6

Equilibrium
Why do we Need an Equilibrium Concept

Example of equilibrium fallacy:

*Here is a great way to warm up the house: On Dec 1st turn the heating up to 70. Once the house gets to 70, turn them off for the rest of the winter, that’s it the house will remain at 70. We might need to turn AC ON on May 1st...*

Some potential fallacies:

- Suppose government consumption (G) Increases by 20%
  - what happens to C and I?

- Suppose government subsidizes employment?
  - what happens to wages?
A Note on Aggregation

Remember:

- Our consumer is a representative consumer: it represents ALL of the consumers in the US
- Our firm is a representative firm: it represents ALL of the firms in the US

Equilibrium

The idea:

1. Set some external conditions (exogenous variables)
2. Determine what happens to all of the other variables of interests (endogenous variables)

In our static model:

1. Exogenous variables: \((K, G, z)\)
2. Endogenous variables: \((C, N^s, N^d, T, Y, w)\)

Notation: \(N^d = \text{labor demanded}; N^s = \text{labor supplied}\)

Equilibrium

How do we know what is going to happen?

1. Must be optimal:
   - everybody (household and firm) must like the decision it has taken.
2. Must be feasible:
   - cannot have more consumption than goods produced.
Definition (Competitie Equilibrium)

For a set of exogenous variables \((K, G, z)\) a competitive equilibrium is a set of endogenous variables \((C, N^s, N^d, T, Y, w)\), so that:

1. The consumer chooses \(C\) (consumption) and \(N^s\) (labor supply) optimally, taking as given \(w\) (wage), \(T\) (taxes), \(\pi\) (dividends).
2. The firm chooses \(N^d\) (labor demand) to maximize profits, taking as given \(w\) (wage), \(K\) (capital stock), \(z\) (productivity).

Turn to next page...

Definition (Competitie Equilibrium (continued))

[... ] continued:

3. Government balances the budget: \(G = T\)
4. Labor market clears: \(N^d = N^s\)
5. Goods market clears: \(Y = C + G\)

Question: nice definition, but does it exist?
Answer: YES! (take my word, or better take theirs nobelprize.org)

Working With the Model

Next step is to characterize the equilibrium:

- Our first approach: find a graphical summary representation
  - The production possibility frontier (PPF)
- Then: characterize equilibrium by solving system of nonlinear equations.
Working With the Model

Derive a relation (production possibility frontier - PPF) so that given \((K,G,z)\) we can determine all the feasible \((C,l)\) pairs

\[ Y = zF(K,N^d) \]

since market clear \(N^d = N^s:\)

\[ Y = zF(K,N^s) \]

substitute feasibility of hours of household: \(N^s = h - l\)

\[ Y = zF(K,h - l) \]

substitute the goods market clearing: \(Y = C + G\)

\[ C = zF(K,h - l) - G \]

The Production Possibilities Frontier

Some properties of the PPF:

\[ C(l) = zF(K,h - l) - G \]

1. Equilibrium consumption decreasing in leisure: \(\frac{dC(l)}{dl} = -z\frac{dF(l)}{dN} < 0\)

2. Decreasing returns - PPF is concave: \(\frac{d^2C(l)}{dl^2} < 0\)
The Marginal Rate of Transformation

Minus the slope of the PPF is the **marginal rate of transformation**

\[ C(l) = zF(K, h - l) - G \]

this implies

\[ MRT_{l,C} = -\frac{dC}{dl} = z \frac{dF(k, h - l)}{dN} = MP_N \]

or in words:

**Marginal rate of transformation = marginal product of labor**

⇒ for any \((C, l)\) on the PPF we can find the wage!

Moving Towards the Competitive Equilibrium

To the production possibilities frontier we need to add:

1. Add the household’s budget constraint \(C = w(h - l) + \pi - T\)

   ⇒ Find the slope: done

   ⇒ Find the intercept: in appendix

2. Add indifference curves.

The Competitive Equilibrium

![Graph showing consumption, production possibilities frontier, and competitive equilibrium.](image)
Algorithm to find a Competitive Equilibrium:

1. Find the values of capital ($K$), government expenditures ($G$) and productivity ($z$): these are the exogenous variables.
2. Given exogenous variables determine PPF,
3. Find point of tangency between PPF and preferences,
4. Recover endogenous variables ($C, N^s, N^d, T,Y,w$).
5. Use the constructed equilibrium to determine relationship between exogenous and endogenous variables: comparative statics.

APPENDIX: Adding The Consumer

We show that the segments $ADB$ constitute the budget constraint

Step 1: segment $AD$ has slope $-w$
Step 2: Need to show that segment $DB$ is of length $\pi - T$

To see this note that
- Segment $D'D$ has length $h - l* = N^*$
- So that segment $JD'$ has length $wN^*$
- Since $J$ is at hight equal to $C^*$ it follows that

$$DB = J - JD'$$

$$DB = C^* - wN^* = \pi - T$$

Online Survey!

Q: Suppose the government increases expenditures by $\Delta G$.
What happens to GDP

A: Your answer here: http://tinyurl.com/73240-ales
Examples

We are going to consider the following two \textit{exogenous} changes:


2. Changes in productivity: $z$.

Government Spending

Suppose the government increases its expenditure: $\Delta G > 0$.
Government Spending

Suppose the government increases its expenditure: \( \Delta G = G_2 - G_1 > 0 \)

1. Balanced budget → if \( G_2 > G_1 \) then \( T_2 > T_1 \);
2. Reduces household’s disposable income → \( C_2 < C_1 \) and \( l_2 < l_1 \);
3. Increase in equilibrium hours worked: \( N_2 > N_1 \) implies \( Y_2 > Y_1 \).

Question 1: \( \Delta C \) vs. \( \Delta G \)?

Question 2: what has happened to the real wage?

Question 3: does GDP increase?

Question 4: does the household prefer the increase in \( G \)?

The effects of government spending: DATA

Suppose the government increases its expenditure: \( \Delta G > 0 \)

Testing the prediction of the model: \( \Delta G \)

- Look at the relation between \( \Delta G \) and \( \Delta C \) (we expect a negative correlation)
- Look at the relation between \( \Delta G \) and \( \Delta N \) (we expect a positive correlation)

For \( G \) and \( C \) we use NIPA table 1.1.6:
http://www.bea.gov/

For \( N \) we use FRED:
http://research.stlouisfed.org/fred2/series/CE16OV?cid=12
Suppose there is an increase in TFP: $\Delta z > 0$

Summarizing:

1. $z_1 \Rightarrow z_2$ with $z_2 > z_1$
2. Wage increases $w_2 > w_1$
3. Consumption increases $C_1 \Rightarrow C_2$
4. Hours worked? depends on Income and Substitution effects

Separating Income and Substitution Effects

$PPF_3$ is $PPF_2$ adjusting the income of the HH so that it’s indifferent between new and old equilibrium
Testing the prediction of the model: $\Delta z$

- Look at the relation between $\Delta z$ and $\Delta C$
  (we expect a positive correlation)

- Look at the relation between $\Delta z$ and $\Delta N$
  (we expect a positive correlation)

For $G$ and $C$ we use NIPA table 1.1.6:
http://www.bea.gov/

For $N$ we use FRED:
http://research.stlouisfed.org/fred2/series/CE16OV?cid=12

For $K$ use Private nonresidential fixed assets:
line 1 of Table 4.1 of the NIPA fixed asset tables:
http://www.bea.gov/national/FA2004SelectTable.asp
Chapter 7

Optimality
Efficiency: Pareto Optimality

Efficiency

Idea:

• Up to now we showed what is going to happen in equilibrium.
• Now we determine what should happen in equilibrium.

Why do we care? Think about a role for the government.

Definition

Pareto Optimality

An equilibrium is Pareto optimal if there is no rearrangement of production or consumption that makes the consumer better off.

The Pareto optimum is chosen by a social planner that:

1. Allocates factors to production, consumption and leisure to maximize the utility of the household.
2. Does not use markets.
3. Is only subject to feasibility.
The Planner Problem

The planner solves

$$\max_{C,l} U(C,l)$$

subject to

$$C = zF(k, h - l) - G$$

Optimality implies:

$$zF_N(k, h - l) = \frac{U_L(C, l)}{U_C(C, l)}$$

Those equations also characterize a competitive equilibrium, so...

---

Pareto Optimality

**Theorem**

*First Welfare Theorem* First welfare theorem: a competitive equilibrium is Pareto optimal.

---

The First Welfare Theorem

A.k.a: why do we like markets so much

- Competitive markets achieves the optimal allocation
  \(\Rightarrow\) It seems that government are at best useless.

- However, how many assumptions did we use to get here?
  \(\Rightarrow\) Government might have a role after all.

- When do we fail to have Pareto optimality?
  
  1. Externalities (pollution)
  2. Missing markets (financing frictions, moral hazard)
  3. Non competitive firms
Theorem (Second Welfare Theorem)

Second welfare theorem: a Pareto optimum is a competitive equilibrium.

This last theorem would not be so obvious if you had two types of consumers.
7.1 Optimal Taxation
Optimal Taxation

1. General Principles
2. Distortionary effects of taxation
3. Optimal taxes at the top
4. The Laffer Curve

Great Source for Data:
http://www.taxpolicycenter.org/taxfacts/

Let’s begin with an example:

Federal Taxes

What is the profile of taxes in the data?

2. Federal Average Tax Rates by Income Groups (individual+corporate+payroll+estate taxes)

Source: Piketty and Saez (2007)

Note: Missing State and Local and FICA.
In the rest of the lecture we will study marginal taxes on income.

Let’s be concrete:

\[ c = (1 - \tau(z)) \cdot w \cdot (h - l) + \pi \]

The tax rate \( \tau(z) \) depends on labor income \( z \).

Some definitions:

1. Tax liability \( \tau(z) \cdot z \).
2. Marginal Tax Rate (MTR). The idea: \( \textit{MTR tells me what fraction of one more dollar earned do I “take home”}. \)

\[ MTR = \tau'(z). \]

---

**Definition (Progressive/Regressive Tax System)**

A Tax system is progressive (regressive) if the Marginal Tax Rate is increasing (decreasing) in income: \( \tau'(z) \) increasing (decreasing) in \( z \).

A Progressive tax system reduces after tax income inequality.

---

**Marginal Rates**

Is The U.S Federal Tax Code Progressive of Regressive ?

<table>
<thead>
<tr>
<th>If your filing status is Single</th>
<th>If your filing status is Married filing jointly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taxable Income</strong></td>
<td><strong>Taxable Income</strong></td>
</tr>
<tr>
<td>Over …</td>
<td>over …</td>
</tr>
<tr>
<td>$0</td>
<td>$9,075</td>
</tr>
<tr>
<td>$9,075</td>
<td>$36,900</td>
</tr>
<tr>
<td>$36,900</td>
<td>$99,350</td>
</tr>
<tr>
<td>$89,350</td>
<td>$189,350</td>
</tr>
<tr>
<td>$189,350</td>
<td>$405,100</td>
</tr>
<tr>
<td>$405,100</td>
<td>$406,750</td>
</tr>
<tr>
<td>$406,750</td>
<td>and over</td>
</tr>
</tbody>
</table>

Source: IRS (2014)
Why does the government use proportional taxes?

- Easy to administer.
- Allows for redistribution of resources (progressive vs. regressive)

A major downside:

- Are taxes efficient? Do the welfare theorems hold?

---

The Distortionary Effects of Taxation

- Government expenditure is to be financed through tax $\tau$
- Does the first welfare theorem hold?
- The Household’s maximization problem is now:

$$\max_{c,l} u(c,l) + \lambda [(1 - \tau)w(h - l) + \pi - c]$$

\textbf{Budget Constraint}

---

Optimality conditions for the household:

\begin{align*}
(C) : & \quad U_c(c,l) - \lambda = 0 \\
(l) : & \quad U_l(c,l) - \lambda(1 - \tau)w = 0 \\
(\lambda) : & \quad (1 - \tau)w(h - l) + \pi - c = 0
\end{align*}

So that

$$\frac{U_l(c,l)}{U_c(v,l)} = (1 - \tau)w$$

Substituting

$$MRS_{l,c} = (1 - \tau)MP_N \Rightarrow MRS_{l,c} < MP_N$$

The competitive equilibrium is not Pareto optimal!
Why does the government use proportional taxes?

- Easy to administer.
- Allows for redistribution of resources (progressive vs. regressive)

A major downside:

- Are taxes efficient? Do the welfare theorems hold?

⇒ The answer to both questions is NO! Proportional taxes should then be used in “moderation”.

---

### What Should Taxes Be?

---

### An Utopian Goal

- Suppose there are $N$ individuals with incomes $z_1 < z_2 < \ldots < z_N$

- Suppose the government cares equally about all of them.

Social welfare is:

$$W = \sum_{i=1}^{N} u(c_i), \quad s.t. \quad c_i = (1 - \tau(z_i))z_i.$$ 

and subject to government budget constraint:

$$\sum_{i=1}^{N} \tau(z_i)z_i = G.$$ 

Where $c_i$ is consumption and $\tau(\cdot)$ are taxes on $z_i$. 

---

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An Utopian Goal: Optimal Taxation

- Planning Problem choose taxes to maximize welfare:

\[
\max_{\tau(z_i)} \sum_{i=1}^{N} u((1 - \tau(z_i))z_i), \quad s.t. \sum_{i=1}^{N} \tau(z_i)z_i = G
\]

- What should taxes be?
- From first order conditions (\(\lambda\) multiplier on budget constraint)

\[
u'((1 - \tau(z_i))z_i) = \lambda
\]

The above implies that for all \(i\) and \(j\):

\[(1 - \tau(z_i))z_i = (1 - \tau(z_j))z_j\]

Full redistribution. What is the problem with this?

---

General Principles

- What are the tradeoffs for choosing taxes?

  1. Equity Considerations.

     For example the relative welfare weights of top earners v.s. the rest.

  2. Efficiency Considerations.

     Behavioral responses from high taxes.

---

Behavioral Effects

In Data do we observe behavioral responses from taxation?

Taking Stock

Some lessons learned from optimal taxation:

1. In the U.S. and most countries taxes on income are proportional. (sometimes referred as marginal taxes)
2. The U.S. tax system is in most part progressive.
3. Proportional taxes make the equilibrium inefficient.
4. If we ignore individual responses, then optimal taxes should be completely redistributive.

Tax Reform

• The goal is to now derive a simple formula for optimal taxes.
• A “Tax Reform”: suppose the government increases taxes by $\Delta \tau$ on individual earning more than $z^*$.
• What happens to revenues? how do tax payer respond?

Definition (“e”)

Elasticity of reported income with respect to the net-of-tax rate $1 - \tau$.

$$e = \frac{1 - \tau}{z} \frac{dz}{d(1 - \tau)}$$
Online Survey!

Q: In your opinion what is a reasonable value for “e”. That is, if taxes go up by 1% by how much would your income go down by?

A: Your answer here: http://tinyurl.com/73240-ales

Tax Reform

- Any individual with income $z > z^*$ changes taxes paid by:

  **Benefit** $\Delta \tau (z - z^*)$.

- Due to behavioral responses income changes by:

  **Cost** $\tau \Delta z = -\Delta \tau \cdot e \cdot z \cdot \frac{\tau}{1 - \tau}$.

- Combining the two effects so that cost and benefit are zero:

  $\Delta \tau \left[ (z - z^*) - e \cdot z \cdot \frac{\tau}{1 - \tau} \right] = 0$

Source: Diamond, Saez (2011)
Combining the two effects so that cost and benefit are zero

\[ \Delta \tau \left[ (z - z^*) - e \cdot z \cdot \frac{\tau}{1 - \tau} \right] = 0 \]

Algebra...

\[ \frac{1 - \tau}{\tau} = \frac{e \cdot z}{z - z^*} \]

Let \( a = \frac{z}{z - z^*} \), more algebra...

\[ \tau = \frac{1}{1 + a \cdot e} \]

Tax Reform: A formula

Definition ("e")

Elasticity of reported income with respect to the net-of-tax rate \( 1 - \tau \).

\[ e = \frac{1 - \tau}{z} \frac{dz}{d(1 - \tau)} \]

- Balancing the tax increase and behavioral response we get:

\[ \tau = \frac{1}{1 + a \cdot e} \]

- The value of \( a = 1.5 \) is not controversial
  (connected with the Pareto distribution of income).

- The values of \( e \) is controversial (estimates range from 0.25 to 2).

- Taxes ranges from ?? to ??

Back To a “Simple” Case
Optimal Taxation: Maximizing Revenue

We now simplify the analysis assuming everybody is the same and government wishes to maximize revenue.

- Household preferences: \( U(c, l) = \log(v) + \log(l) \)
- Household budget constraint: \( c = (1 - \tau) \cdot w \cdot (h - l) + \pi \)
- Assume \( F(K, N) = zN \Rightarrow \text{wages are fixed!} \)

Government revenues are

\[
R(\tau) = \tau \cdot w \cdot (h - l)
\]

Suppose the government has the goal of maximizing revenues.

**Optimal Taxation: Maximizing Revenue**

- From first order conditions of households we get
  \[
c = (1 - \tau) \cdot w \cdot l
\]
- Substituting the above in the budget constraint
  \[
w l = \frac{wh}{2} + \frac{\pi}{2(1 - \tau)}
\]
- Substituting the above in the expression for revenues \( R(\tau) \) we get
  \[
R(\tau) = \tau wh - \tau wl \Rightarrow \frac{\tau hw}{2} - \frac{\tau}{1 - \tau} \frac{\pi}{2}
\]

**Optimal Taxation: Maximizing Revenue**

- Revenues:
  \[
R(\tau) = \frac{\tau hw}{2} - \frac{\tau}{1 - \tau} \frac{\pi}{2}
\]
- The objective of the government can be written as
  
  Set \( \tau \) so that \( R(\tau) = G \)

- Note that \( R(0) = R(1) = 0 \ldots \) must be curved!

- \( R(\tau) \) is also called in a different way:
  
  ![YouTube Video](http://www.youtube.com/watch?v=dxPVyieptwA)
The Laffer Curve

\[ R(\tau) = \frac{\tau hw}{2} - \frac{\tau}{1 + \frac{\pi}{2}} \]

- KEY: besides the maximum revenue there are always two tax rates that provide the same revenue.
- Since tax are distortionary it is always better to choose a small \( \tau \).

Taking Stock

Some lessons learned from optimal taxation:

1. In the U.S. and most countries taxes on income are proportional. (sometimes referred as marginal taxes)
2. The U.S. tax system is in most part progressive.
3. Proportional taxes make the equilibrium inefficient.
4. If we ignore individual responses, then optimal taxes should be completely redistributive.
5. Quantitatively taxes at the top should be fairly high!
6. But not so high as being on the “wrong side” of the Laffer Curve.
Chapter 8

Growth
In 2008:

![Global Income Distribution Map](image)

**Figure 1.2** Estimates of the distribution of countries according to log GDP per capita (PPP adjusted) in 1960, 1980, and 2000.

Source: Acemoglu (2008).

**Slide 5 of 32**

**Income Per Capita Over Time**

As a histogram:

![Income Distribution Histogram](image)

Source: Acemoglu (2008).

**Slide 6 of 32**

**Income Per Capita Over Time**

How did we get there:

![Income Evolution Graph](image)

Source: Acemoglu (2008).
• Existence of large and sustained growth: (recall the 2% per year for the US)

• Existence of growth miracles: (South Korea, Singapore, Japan)

• Existence of growth disasters: (Venezuela, North Korea, Most of South Saharan Africa)

Modern Growth Rates

The distribution of growth rates:

Slide 7 of 32

A Useful Formula

• How to visualize growth rates more directly?

• Let’s determine the time to double in size. Recall:

\[ x_t = x_0 e^{\gamma t} \]

where \( \gamma \) is the growth rate (not in %).

• Let \( T \) the time required to go from \( x_0 \to 2x_0 \)

\[ 2x_0 = x_0 e^{\gamma T} \Rightarrow T = \frac{\ln 2}{\gamma} \]

• Also know as rule of 70:

\[ T = \frac{\ln 2}{\gamma} \approx \frac{7}{\gamma} \approx \frac{70}{\gamma\%} \]

Where \( \gamma\% \) is now in percentage terms.

Source: Acemoglu (2008).

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Modern Growth Rates

The distribution of growth rates:

<table>
<thead>
<tr>
<th>Average annual growth rate</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5% - 2.5%</td>
<td>China</td>
</tr>
<tr>
<td>2.5% - 3.5%</td>
<td>Brunei</td>
</tr>
<tr>
<td>2.5% - 4.5%</td>
<td>Kyrgyzstan</td>
</tr>
<tr>
<td>3.5% - 4.5%</td>
<td>South Korea</td>
</tr>
<tr>
<td>4.5% - 5.5%</td>
<td>Malta, Myanmar</td>
</tr>
<tr>
<td>5.5% - 6.5%</td>
<td>Malaysia</td>
</tr>
<tr>
<td>6.5% - 7.5%</td>
<td>Thailand</td>
</tr>
<tr>
<td>7.5% - 8.5%</td>
<td>Hong Kong</td>
</tr>
<tr>
<td>8.5% - 9.5%</td>
<td>Ireland, Sri Lanka</td>
</tr>
<tr>
<td>9.5% - 10.5%</td>
<td>Indonesia</td>
</tr>
<tr>
<td>10.5% - 11.5%</td>
<td>Luxembourg, India, Romania, Hungary</td>
</tr>
<tr>
<td>11.5% - 12.5%</td>
<td>Norway, Peru, Egypt, Poland</td>
</tr>
<tr>
<td>12.5% - 13.5%</td>
<td>United States, Pakistan, Japan, Chile, Greece, Canada</td>
</tr>
<tr>
<td>13.5% - 14.5%</td>
<td>France, Belgium, Israel, Brazil, Mongolia, Brazil</td>
</tr>
<tr>
<td>14.5% - 15.5%</td>
<td>Philippines, Mexico, Uruguay, New Zealand</td>
</tr>
<tr>
<td>15.5% - 16.5%</td>
<td>Nigeria, Singapore, Rwanda, Eritrea</td>
</tr>
<tr>
<td>16.5% - 17.5%</td>
<td>Chad, Jordan, Saudi Arabia, Nepal</td>
</tr>
<tr>
<td>17.5% - 18.5%</td>
<td>Venezuela, Solomon Islands, Burundi</td>
</tr>
<tr>
<td>18.5% - 19.5%</td>
<td>Zambia, Niger, Ethiopia</td>
</tr>
<tr>
<td>19.5% - 20.5%</td>
<td>Gabon, Central African Republic</td>
</tr>
<tr>
<td>20.5% - 21.5%</td>
<td>Namibia, Namibia</td>
</tr>
<tr>
<td>21.5% - 22.5%</td>
<td>Kuwait</td>
</tr>
<tr>
<td>22.5% - 23.5%</td>
<td>Benin</td>
</tr>
<tr>
<td>23.5% - 24.5%</td>
<td>Democratic Republic of Congo</td>
</tr>
</tbody>
</table>

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Source: Acemoglu (2008).

HISTORICAL GROWTH

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Income Per Capita Over Time

How did we get there:

FIGURE 1.11 The evolution of average GDP per capita in Western Offshoots, Western Europe, Latin America, Asia, and Africa, 1000–2000.
What happened before 1800?

- Growth Was Slow! World GDP growth was:
  1. Between 1700-1820: 0.07%
  2. Between 1500-1700: 0.04%

- Long-term cycles.

- Huge changes in relative rankings (Rome, China, Incas, Haiti).

- Little difference between countries:
  (Rich to poor ratio $\approx 2$)

Taking Stock

- So far the following questions have emerged:
  1. How can some countries sustain stable growth?
  2. Why do some countries go much faster than others?
  3. Why are some countries not growing?
  4. Why was the world not growing before the 19th century?

Question for review:

- Is the World accelerating?

- Is there a Widening gap between rich and poor?
What Determines Growth?

- First step find the data!
- Great sources:
  1. Penn World Tables:
     https://pwt.sas.upenn.edu/php_site/pwt71/pwt71_form.php
  2. IMF World Economic Outlook Database:

Investment is positively correlated with GDP levels.

What Determines Growth?

More on investment:

![Graph showing the relationship between average growth of GDP per capita and average growth of investments to GDP ratio, 1960–2000.](image)

Source: Acemoglu (2008)
What Determines Growth?

Population growth?

Levels of GDP?

Schooling

- Population growth is negatively correlated with GDP levels.
- Levels of GDP are not correlated with GDP growth rates.
- Schooling levels are positively correlated with GDP growth rates.
This is why we need a model!!! Latitude is \textbf{positively correlated} with GDP levels and growth rates!

\begin{center}
\textbf{WELFARE AND INEQUALITY}
\end{center}

\begin{itemize}
  \item Does growth \textbf{Increase Welfare}?
  
  \item Economists define welfare as the expected lifetime utility for all individuals in a country.

  \item To make things simple suppose that welfare depends on: (i) life expectancy ($H$) and (ii) income ($y$). We have:
  \[
  W = H \cdot E[u(y)]
  \]
  
  where $W$ is average welfare. $E[\cdot]$ is an expectation.
\end{itemize}
• Let $\overline{y}$ be the average income in a country.

• We can approximate $E[u(y)]$ taking second order Taylor expansions around $\overline{y}$. We have:

$$E[u(y)] = u(\overline{y}) + u'(\overline{y}) \cdot E[(y - \overline{y})] + \frac{u''(\overline{y})}{2} E[(y - \overline{y})^2]$$

Growth and Welfare

• Simplifying

$$E[u(y)] = u(\overline{y}) + u'(\overline{y}) \cdot \underbrace{E[(y - \overline{y})]}_{=0 \text{ by definition}} + \frac{u''(\overline{y})}{2} \underbrace{E[(y - \overline{y})^2]}_{\text{Variance of income}}$$

• So that welfare is

$$W = H \cdot [u(\overline{y}) + \frac{u''(\overline{y})}{2} Var[y]]$$

• This implies that Welfare:
  1. Is increasing in life expectancy
  2. Is increasing in income per capita
  3. Is decreasing in the variance of income (recall $u''$ is negative!)

Welfare: Consumption

Relationship with consumption:

Source: Acemoglu (2008).
Relationship with life expectancy:

**Figure 1.6** The association between income per capita and life expectancy at birth in 2000.

Source: Acemoglu (2008).

### Inequality Over Time

Decomposing inequality between and within countries:

- Inequality **between** countries in increasing
- Inequality **within** countries is decreasing

\(^2\)See appendix for formal definition of inequality

### Wealth Share at the Top

- What about inequality the US?
8.1 Malthus and Solow
Two Models of Growth

Two model main difference is in the production function:

- **Malthus**
  \[ Y = zF(\frac{L}{\text{land}}, N) \]

- **Solow**
  \[ Y = zF(\frac{K}{\text{capital}}, N) \]

\( N = \text{ labor} \)
\( L = \text{ land} \)
\( K = \text{ capital} \)
\( z = \text{ productivity (TFP)} \)

Note: new ingredient \( \rightarrow \text{ land} \)

Key difference:

- \( L = \text{ land} \) is in fixed supply
- \( K = \text{ can be accumulated over time} \)

- We will use two models to describe growth facts both ancient (Malthus) and modern (Solow).
- Hansen-Prescott in the paper entitled *Malthus to Solow* describe how society switched from one regime to the other.

Malthusian Model

1. Technology: \( Y = zF(L, N) \)
   - assume constant return to scale

2. Preferences: fixed labor supply (we normalize to 1 unit)

3. Population = number of workers
   - Use \( N \) to denote number of workers today;
   - Use \( N' \) to denote number of workers tomorrow;

Question: what determines population growth?
Malthusian Model: Population Growth

- Key assumption:
  
  **Growth rate of population depends on living standards.**

- Living standard are related to consumption per capita:

  \[
  \text{LIVING STANDARDS} = \frac{C}{N}
  \]

- We have:

  \[
  \frac{N'}{N} = g\left(\frac{C}{N}\right)
  \]

  \(g(\cdot)\) increasing and concave function;

---

**Equilibrium in the Malthusian Model**

Equilibrium is standard: Agents and firm optimize, market clearing...
plus: steady state in the population \(N' = N = N^*\)

Equilibrium is determined by:

1. Market Clearing for goods market:

   \[C = Y = zF(L, N)\]

2. Steady State condition:

   \[N' = N \quad \text{(A)}\]

3. Population growth equation:

   \[
   \frac{N'}{N} = g\left(\frac{C}{N}\right).
   \]

---

Equilibrium in the Malthusian Model

- Substitute \(C\) in population growth equation:

  \[
  \frac{N'}{N} = g\left(\frac{zF(L, N)}{N}\right)
  \]

- Using our constant return to scale assumption:

  \[
  \frac{N'}{N} = g\left(\frac{zF\left(\frac{L}{N}, 1\right)}{N}\right) \quad \text{(B)}
  \]

  where \(L/N = \text{land per capita}\)
• We now have two equilibrium conditions:

\[(A) \Rightarrow N' = N\]

\[(B) \Rightarrow \frac{N'}{N} = g\left(zF\left(\frac{L}{N}, 1\right)\right)\]

• Combining (A) and (B):

\[g\left(zF\left(\frac{L}{N}, 1\right)\right) = 1\]

Equilibrium: Example

• Let \(F(L, N) = zL^{\alpha}N^{1-\alpha}\) and \(g(\cdot) = (\cdot)^{\gamma}\), then

\[N' = z^{\gamma}L^{\alpha^{\gamma}}N^{1-\alpha^{\gamma}}\]

recall \(\alpha < 1\) and \(\gamma < 1\).

• Equilibrium exist: \(N^*\)

(intersection of 45 degree line and concave curve)

• Note: is there another equilibrium?
• We have large technology developments prior to industrial revolution

• If \( z \) has always been increasing, why have standard of living been stagnating for centuries?

Malthusian Model: Analysis

What happens if \( z \) increases at a time \( T = 1 \)?

Recall that in steady state:

\[
g\left(\frac{C_1^*}{N_1^*}\right) = 1 \tag{B}
\]

\[C_1^* = z_1 F(L, N_1^*)\]

If \( z_1 \uparrow z_2 \) (with \( z_1 < z_2 \)) then:

1. \( C_1^* < z_2 F(L, N_1^*) \), so \( C_1^* \) must increase to \( C_2^* \)

2. From equation (B): \( g\left(\frac{C_2^*}{N_2^*}\right) > 1 \) so \( N_1^* \) must increase to \( N_2^* \)

3. Converge to new steady state with \( C_2^* = z_2 F(L, N_2^*) \)
• How can we increase standard of living? Population Control

  \[ \text{Cut population growth by factor } \delta < 1 \]

• New equilibrium conditions become:

  \[
  \delta \cdot g \left( \frac{C^*}{N^*} \right) = 1 \tag{C}
  \]

  \[
  C^* = zF(L, N^*)
  \]

  Compare equation (B) with equation (C).

Cutting population growth rates:

1. The Malthusian model achieve stagnation in growth.
2. Any technological development gets absorbed by larger populations.
3. Land seems to play a key role in depressing growth.
The Solow Growth Model

The Solow Growth Model: Introduction

- Key difference with Malthus: the use of capital
- New Ingredients:
  - Exogenous population growth.
  - Saving ($S$).

The Household

- Exogenous population growth:

\[ N' = (1 + n)N \]

$n$ is the growth rate and $n > -1$

- Households care about consumption, leisure and the future the budget constraint is:

\[ C + \underbrace{S}_{\text{Saving}} = \underbrace{Y}_{\text{Income}} \]

- For now: “rule of thumb” for saving

\[ S = sY \quad \Rightarrow \quad C = (1 - s)Y \]

household save a constant fraction of their income
Capital and the Firm

- Production function:
  \[ Y = z F(K, N) \]

  Note for now \( z \) is **exogenous**.

- New ingredient: law for capital accumulation

  \[ \frac{K'}{K} = (1 - d) + I \]

  where \( I \) is investment and \( d \) is the depreciation rate: \( 0 < d < 1 \)
What is the value of $d$ for the US?


<table>
<thead>
<tr>
<th>Type of asset</th>
<th>Depreciation rate</th>
<th>Service life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing equipment</td>
<td>.3119</td>
<td>7</td>
</tr>
<tr>
<td>Aircrafts 1960 and later</td>
<td>.0660</td>
<td>25</td>
</tr>
<tr>
<td>General industrial equipment</td>
<td>.1072</td>
<td>16</td>
</tr>
<tr>
<td>Agricultural machinery</td>
<td>.1179</td>
<td>14</td>
</tr>
<tr>
<td>Industrial buildings</td>
<td>.0314</td>
<td>31</td>
</tr>
<tr>
<td>Submarines</td>
<td>.0825</td>
<td>20</td>
</tr>
</tbody>
</table>

The Firm

- Maximizes profits:

$$\pi(K) = \max_{I,N} \left\{ Y - wn - I + \underbrace{\pi(K')}_{\text{Profits Tomorrow}} \right\}$$

Subject to

$$Y = zF(K,N)$$

And

$$K' = (1-d)K + I$$

Equilibrium and Steady State

1. Firm and Household optimize.
2. Market clearing for goods:

$$Y = C + S$$
3. Market clearing for assets (NEW!):

$$S = I$$

This implies that all investments comes from saving.
Steady State

• In Malthus steady state was $N = N' = N^*$

• In Solow population always grows,
  ➔ use notion of per capita steady state

$$\frac{K'}{N'} = \frac{K}{N} = k^* \Rightarrow k' = k = k^*$$

$$\frac{Y'}{N'} = \frac{Y}{N} = y^* \Rightarrow y' = y = y^*$$

• From now on lower case letters denote per-capita quantities, also

$$F(K, N) = F\left(\frac{K}{N}, 1\right) = f(k)$$

Kaldor Facts

Facts about economic growth proposed by Kaldor in 1961

1. $\frac{Y}{N}$ increases at a constant rate over time

2. $\frac{K}{N}$ increases at a constant rate over time

3. $\frac{K}{Y}$ remains constant

Steady state assumption seems justified...

Can one of the above help me figure out $K$?

Solving For the Steady State

• Our goal is now to derive a condition for equilibrium value of $k$.

  This is important to understand questions like:

  1. How to foster growth?
  2. Why is the saving rate important?
  3. Is a capital tax good or bad?

• Algebra ahead: take a deep breath!!
Solving For the Steady State

Start:

\[ K' = (1 - d)K + I \]

Substitute \( I \) from market clearing for goods and assets:

\[ Y = C + K' - (1 - d)K \]

Substitute rule of thumb for saving and production function:

\[ Y = (1 - s)Y + K' - (1 - d)K \quad \Rightarrow \quad K' = szF(K, N) + (1 - d)K \]

Divide by \( N \)

\[ \frac{K' N'}{N N'} = \frac{szF(K, N)}{N} + \frac{(1 - d)K}{N} \]

Recall that \( N' = (1 + n)N \)

\[ k' (1 + n) = szf(k) + (1 - d)k \]

since in steady state \( k = k' \)

\[ szf(k) = (n + d)k \]

---

Analysis of the Steady State

Key equilibrium condition:

\[ szf(k^*) = (n + d)k^* \]

To understand it, graph both sides of the equation:

What happens if \( s, n, d, z \) changes?

---

Changing the Saving Rate

- Suppose \( s \) changes: \( s_1 \) to \( s_2 \) \((s_2 > s_1)\)

- \( k_1 \) increases to \( k_2 \)

- Question: what happens to \( y_1 \)?
Recall that in equilibrium saving = investment.

Investment is positively correlated with GDP levels.

Changing the Population Growth Rate

• Suppose $n$ changes: $n_1$ to $n_2$ ($n_2 > n_1$)

• $k_1$ decreases to $k_2$

Population growth is negatively correlated with GDP levels.
Growth

Growth Rates

- In Malthus consumption per capita is constant over time.

- Question 1: how is consumption, output and capital growing over time?

- Question 2: how is consumption, output and capital per capita growing over time?

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Growth Rates

What is the growth rate of $K,C,Y$ in steady state?

\[ k' = k \Rightarrow \frac{K'}{N'} = \frac{K}{N} \]

so that

\[ K' = \frac{N'}{N} K = (1 + n)K \]

growth rate is the population growth rate!

(Same for $Y$ and $C$)

Question: how do you show it for $Y$?

(hint you will need CRS assumption for $F$)
Growth Rates

- Question 1: how is consumption, output and capital growing over time?
- Answer 1:
  \[ Y, C, K \text{ grow at rate } n, \text{ the population growth rate.} \]
- Question 2: how is consumption, output and capital per capita growing over time?
- Answer 2:
  The above implies that \[ \frac{K}{N} \] is constant over time...as Malthus?

Something is now very different than Malthus...

Sustaining Growth

To sustain growth over time we need something other than \( s \) and \( n \): \( z \)

Increasing \( z_1 \rightarrow z_2 \rightarrow z_3 \) generates long term growth!

The Solow Residual

- We have identified \( z \) as a key source for growth. \( z \) is sometimes called the Solow Residual.
- Key question, what is \( z \) in the data, how do we calculate it?
- From equilibrium condition:
  \[ Y = zF(K, N) = zK^\alpha N^{1-\alpha} \]
  hence
  \[ z = \frac{Y}{F(K, N)} = \frac{Y}{K^\alpha N^{1-\alpha}} \]

We need information on: GDP \( (Y) \)...easy, Workers \( (N) \)...easy, \( \alpha \) not easy but done, \( K \) hard.
Measuring $K$

- Starting point to determine $K_{t+1}$ (at time $t+1$) is:
  
  \[ K_{t+1} = (1 - d)K_t + I_t \]

- We have information on $I_t$ since 1947 but we do not know $K_{1947}$

- Idea from Kaldor: set $K_{1947}$ so that over time $K_t/Y_t$ is roughly constant

- If $K_{1947}$ is set too high then $K_t/Y_t$ will decrease over time.
  If $K_{1947}$ is set too low then $K_t/Y_t$ will grow over time.

- As a rule of thumb it is ok to set $K_{1947}$ so that $K_{1947}/Y_{1947} = 3$.

---

The Solow Residual

Plotting $z$ (the Solow residual) for the US

---

Cross Country Convergence
Q: If the world was described by a Solow model, what would happen eventually to identical countries with different level of GDP per capita $y_{poor}$ and $y_{rich}$ today?

$y_{poor} = zf(k_{poor}) \quad y_{rich} = zf(k_{rich})$

If today $y_{poor} < y_{rich}$ it implies $k_{poor} < k_{rich}$...

what happens in steady state?

Key equation:

$$szf(k) = (n + d)k$$

A: In the long run, they will have the same level of gdp per capita

Is this happening?

Cross Country Convergence: Eastern Europe


Here is an example of countries converging.

However looking across all countries...
...not quite

Levels of GDP are not correlated with GDP growth rates.

Convergence: An Explanation

What is wrong with the model?

1. Maybe all the countries are not the same
2. Barriers to technology adoption
3. Barriers to investment
4. Non optimizing firms?

If interested, see also Parente, Prescott (2000).

If really interested take my class in the Fall: Emerging Markets.
8.2 Endogenous Growth Model
Endogenous Growth

• Solow explains **why** we have growth: it’s either $z$ or $n$

• Does not tell us what to do to **improve** long run growth: i.e how does $z$ go up?

→ we need to go further and introduce: human capital

Schooling Years

Source: World Bank

→ What can we learn from the above?
### Schooling: Spending

<table>
<thead>
<tr>
<th>Country</th>
<th>% of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yemen</td>
<td>9.5%</td>
</tr>
<tr>
<td>Mongolia</td>
<td>9%</td>
</tr>
<tr>
<td>Kenya</td>
<td>7%</td>
</tr>
<tr>
<td>Switzerland (U.S)</td>
<td>5.8% (5.7%)</td>
</tr>
<tr>
<td>Italy</td>
<td>4.7%</td>
</tr>
<tr>
<td>Zambia</td>
<td>2%</td>
</tr>
<tr>
<td>Ecuador</td>
<td>1%</td>
</tr>
</tbody>
</table>

Source: United Nations

> What can we learn from the above?
Endogenous Growth: Human Capital

Human Capital:

The **stock** of skills and education that workers have at a point in time

Properties:

1. It grows
2. It does not depreciate
3. Technologies using it do not exhibit decreasing returns
4. Is non-rivalrous

A Simple Model: The Consumer

Suppose:

1. There is no leisure:
   - Workers divide their time between **work** and human capital accumulation.
   - Let $N$ denote time at work. $(1 - N)$ time at school.
2. Human capital $H^*$ increase effective time at work: more human capital = more output for the same amount of hours.
3. There is no capital.

A Simple Model: The Consumer

- **Budget constraint:**
  
  $$C = \frac{w}{\text{Wage}} \cdot \frac{N \cdot H}{\text{Effective labor}}$$

  Note that effective amount of labor is now $N \cdot H$ not $N$.

- **Human capital accumulation**
  
  $$H' = b(1 - N)H$$

  $b$ is efficiency of human capital accumulation (quality of schools)
A Simple Model: The Firm

- Firm maximize profits choosing effective labor $N \cdot H$

$$\max_{N,H} zN \cdot H - wN \cdot H$$

Note: we assumed linear firm technology

- Since problem of the firm is linear:
  1. Equilibrium wage is $z$.
  2. Firm is indifferent in choice of $N \cdot H$.

A Simple Model: The Equilibrium

Let’s determine the consumption growth rate

- From budget constraint and firm maximization problem:

$$C = zN \cdot H$$

(note $w = z$) and

$$H' = b(1 - N)H \Rightarrow \frac{H'}{H} - 1 = b(1 - N) - 1$$

- Computing growth rates of consumption:

$$\frac{C'}{C} - 1 = \frac{zNH'}{zNH} - 1 = \frac{H'}{H} - 1 =$$

$$= \frac{b}{\text{efficiency}} \cdot \frac{(1 - N)}{\text{intensity}} - 1$$

A Simple Model: Summary

1. Economy grows indefinitely because of human capital accumulation.

2. Rate of growth determined by intensity and efficiency of human capital accumulation.
A Simple Model: Policy

What are good policies?

1. Increase schooling

2. Increase efficiency of schooling

http://www.worldbank.org/education
Chapter 9

Dynamic Model

9.1 Forecasting: Part 2
Forecasting Part II: Leading Indicators

This Lecture

• Leading Indicators

• Application to Employment Forecasting:
  1. ADP employment Survey
  2. Vacancies

• Application to GDP Forecasting:
  1. Heavy truck sales

Forecasting: Information Sets

Definition (Information Sets)
Let $I_t$ be the set of information available at time $t$ for a forecast.

- In previous lecture we used past information on the variable of interest ($x_t$) to forecast it’s feature.
- In particular we used all of the available past information to forecast via a linear trend. Formally $I_t = \{x_n\}_{n=1}^{t-1}$
- In this lecture we will use other variables to help us forecast $x_t$ so that: $I_t = \{z_n\}_{n=1}^{t-1}$
Leading Indicators

- Setting $I_t = \{z_n\}_{n=1}^{t-1}$ is particularly useful if $z_{t-1}$ “predicts” $x_t$.
- In this case we will call $z_t$ a leading indicator of $x_t$.
- Recall that a leading indicator ($z_t$ in our case) is a variable that over the cycle anticipates the changes of another variable ($x_t$).
- Examples:
  1. Earnings $\rightarrow$ Dividends;
  2. Monetary base $\rightarrow$ Inflation;
  3. ?? $\rightarrow$ Employment;
  4. ?? $\rightarrow$ GDP.

A Simple Model

- Suppose we knew that:

  $$x_t = b_0 + b_1 \cdot z_{t-1} + \varepsilon_t$$  \hspace{1cm} (1)

- Suppose today we observe $z_t$; Then today we can forecast the future value of $x_{t+1}$ by:

  $$x_{t+1} = b_0 + b_1 \cdot z_t$$

Goal: find $b_0$ and $b_1$.

A General Model

- The previous model only consider 1 explanatory variable $z$. We can generalize:

  $$x_t = b_0 + b_1 \cdot z_{t-1} + b_2 \cdot x_{t-1} + b_3 \cdot w_{t-1} + \ldots + \varepsilon_t.$$  

- We now also consider:
  1. Past realization of the variable $x_{t-1}$; (for example if $x$ is GDP is natural to include past values)
  2. Additional explanatory variables $w_{t-1}$.

- The generalization to include additional explanatory variables is conceptually easy. Is harder to implement quantitatively.

Refer to your econometrics class.
Appendix: Which Model to Choose?

- The previous and this lecture point to a variety of modeling approaches. Including different leading indicators or lagged variables.
- Natural question, which is the “best model”?
- Many formal ways to answer this.
  A simple approach is to look at $\varepsilon_t$ the error term.
- In particular we are interested to see if the series $\varepsilon_t$ has “patterns”.

Appendix: Durbin-Watson

- The Durbin-Watson Statistic ($d$) is given by (assuming $\varepsilon$ is of length $T$):
  \[ d = \frac{\sum_{t=2}^{T} (\varepsilon_t - \varepsilon_{t-1})^2}{\sum_{t=1}^{T} \varepsilon_t^2} \]
- $d$ determines how correlated are the error over time. If errors are correlated then one could used past errors to reduce future errors.
- Rule of thumb: the closer $d$ is to 2 the better the model.

A Word of Caution: Lucas 1976

- Consider a simple “econometric” model of the household:
  \[ c_t = b_0 + b_1 \cdot \underbrace{y_t}_{\text{Income}} + b_2 \cdot \underbrace{T_t}_{\text{Transfers}} \]
  parameters $b_0$, $b_1$ and $b_2$ can be estimated looking at past data.
- Suppose a policy maker is considering changing $T_t$ or $T_{t+1}$.
  What mistake he would be making relying on the above model?
  The mistake would be considering $(b_0, b_1, b_2)$ as fixed rather than dependent on policy itself. Households are “smart” and have expectations about future policies!
- Lucas (1976) “Econometric Policy Evaluation: A Critique” makes this points with multiple examples. Since this critiques has be referred to as: The Lucas Critique
BLS Employment Survey

- Policy maker and market pay close attention to the behavior of the labor market as a good indicator of the state of the economy.

- From the BLS: 
  *Each month the Current Employment Statistics (CES) program surveys approximately 144,000 businesses and government agencies, representing approximately 554,000 individual worksites, in order to provide detailed industry data on employment, hours, and earnings of workers on nonfarm payrolls.*

- Note: The CES is an estimate on the number of salary jobs: an individual with two jobs is counted twice by the payroll survey.

- The CES releases monthly, next releases are April 4th and May 2nd.

ADP Employment Report

- ADP (Automatic Data Processing) is a private firm that offers payroll services to other companies.

- ADP process approximately 411,00 US firms (20% of the private sector). This puts ADP on similar footing to the BLS in terms of data owned.

- Every month shortly (few days) before the CES report, ADP releases the National Employment Report.

- Next release dates are April 2nd and April 30th.
• Legend PAYEMS (BLS); NPPTTL (ADP).
• The two series track each other very closely.

Leading Indicator: Job Openings

• The ADP series is released only few days the CES series.
• Other leading indicators are available. A popular one: job openings
• The idea is simple to fill a job, a job must first become available.
• Job openings are published in the JOLTS (Job openings and labor turnover survey)
• The next release date is April 8th.

Vacancies vs. CES

• Job opening “anticipates” the behavior of payroll employment.
Results

• The previous two graphs are displayed as: differences from a year ago.

• This is done to remove possible seasonality effects.

• We compute $b_0$ and $b_1$ in (1) using Excel.

• As before we can use SLOPE to compute $b_1$ and INTERCEPT to compute $b_0$.

• We find:

$$b_0 = -75.11; \quad b_1 = 0.186; \quad d = 0.5$$

• If we use 1 lag of CES as explanatory variable then $d = 2.7$.

Application to GDP Forecasting

Truck Sales

• We now look at GDP more closely.

• The idea is to look at the behavior of firms. Firm, as a whole can internalize the current conditions of the economy.

• In the next class we will see that investment is an important forward looking variable.

• Today we look at one particular investment heavy trucks.

2Heavy trucks are trucks with more than 14,000 pounds gross vehicle weight.
• There appears to be a negative relationship between shaded areas and truck sales.

GDP vs. Truck Sales

• Truck Sales is a good leading Indicator for GDP for the current recession...

Historical Relationship

• ...the relationship seem to be also present in historical data.
9.2 The Household
The Federal Open Market Committee (FOMC) meets 8 times a year to set monetary policy for the US.

On March 19th the FOMC released a statement concerning the latest meeting.

This Meeting was important as it marks the first one chaired by Janet Yellen.

The statement can be found here: http://www.federalreserve.gov/newsevents/press/monetary/20140319a.htm

FOMC statement have a precise structure:
1. Start with an overview of the current economic conditions
2. Relate conditions with the FED mandate
3. Describe the policy taken and how they might impact

Key information that economist look for in FOMC statement is **Forward guidance**:

*Through "forward guidance," the Federal Open Market Committee provides an indication to households, businesses, and investors about the stance of monetary policy expected to prevail in the future.*

Source: http://www.federalreserve.gov/faqs/money_19277.htm

In January:

Committee today reaffirmed its view that a highly accommodative stance of monetary policy will remain appropriate for a considerable time after the asset purchase program ends and the economic recovery strengthens. The Committee also reaffirmed its expectation that the current exceptionally low target range for the federal funds rate of 0 to 1/4 percent will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent.

In March:

Committee currently anticipates that, even after employment and inflation are near mandate-consistent levels, economic conditions may, for some time, warrant keeping the target federal funds rate below levels the Committee views as normal in the longer run.
Q: Suppose this year the economy is in a recession. When should the government levy more taxes?

A: Your answer here: http://tinyurl.com/73240-ales

1 This year
2 Next year
3 At the end of the recession

Plan for This Lecture

1 The two period model: the consumer
   • Inter-temporal budget constraints
   • Household savings data

2 The two period model: comparative statics
   • Changes in wealth
   • Changes in interest rates

3 The two period model: the government
   • Ricardian Equivalence
Two Period Model: Consumer

- Consumers live two periods
- New trade-off: consumption today vs consumption tomorrow
  (add this to the consumption leisure trade-off studied in part I)
- New instrument: bonds $s$
  1. All bonds are identical
  2. All bonds are safe
  3. No intermediaries
- New price: interest rate $r$ (1 bond today, pays $1 + r$ tomorrow)
  4. Borrowers and lenders face the same $r$

Slide 8 of 44

Two Period Model: Budget Constraints

- Budget constraint today:
  $$c + s = y - t$$
- Budget constraint tomorrow: (recall $'$ denotes tomorrow’s variable)
  $$c' = y' - t' + (1 + r)s$$
- Define lifetime wealth (today) as:
  $$we = y + \frac{y'}{1 + r} - t - \frac{t'}{1 + r}$$
  then
  $$c' = -(1 + r)c + we(1 + r)$$

Slide 9 of 44

Two Period Model: Budget Constraints

Plotting the budget constraint

$E = (y - t, y' - t')$ used to determine how income is distributed during the lifetime

Slide 10 of 44
Two Period Model: Optimality

- Households enjoy consumption today and tomorrow
- Households enjoy more the present
- Preferences: 
  \[ u(c) + \beta u(c') \]
  \( 0 < \beta < 1 \): time discount factor; \( u(\cdot) \): standard utility function
- Problem of the household:
  \[
  \max_{c,c'} u(c) + \beta u(c') \\
  \text{Subject to} \quad (1 + r)c + c' = w(1 + r)
  \]

From first order conditions:
\[ u_c(c) = (1 + r)\beta u_{c'}(c') \]

Optimality:
\[
\frac{u_c(c)}{\beta u_{c'}(c')} = (1 + r)
\]

\[ MRS_{c,c'} = 1 + r \]

Intuition:
Give up one consumption today (valued at \( u_{c'}(c') \)) for \((1 + r)\) units of consumption tomorrow (valued at \( u_{c'}(c') \) and discounted by \( \beta \))
Two Period Model: Saving

What are the implication for saving?

1. flat income profile \((y - t = y' - t')\): optimal saving is 0.
2. increasing income \((y - t < y' - t')\): optimal saving is < 0.
3. decreasing income \((y - t > y' - t')\): optimal saving is > 0.

(c) Positive saving  
(d) Negative saving

Two Period Model: Consumption Smoothing

Question: what are the implications for consumption?

• A simple case: let \(\beta = \frac{1}{1+\tau}\). Optimal solution is given by:

\[
u_c(c) = u_c(c') \Rightarrow c = c'
\]

(1)

• Household seeks to equalize his marginal utility over both periods.

• This property is called consumption smoothing
Is there a problem with a **negative** national saving rate?

- This aggregate measure leaves out realized earning in other assets
- This is important especially thinking about retirement
  (if your stock portfolio goes well, you save less)
- Is this impacting the business sector?

A nice article:
http://www.clevelandfed.org/research/trends/2010/0410/01ecoact.cfm

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**TWO PERIOD MODEL: THE GOVERNMENT**

The Dynamic Government

- Government spends and taxes in two periods
- NEW: now it can borrow and save!
- Budget constraint today
  \[ G = T + B \]
- Budget constraint tomorrow
  \[ G' + (1 + r)B = T' \]
- Life-time budget
  \[ G + \frac{G'}{1 + r} = T + \frac{T'}{1 + r} \]
**Ricardian Equivalence**

- **Punchline:** the timing of taxes is irrelevant
- **Key equation:** lifetime budget constraint (in today’s $)

\[
c + \frac{c'}{1 + r} = y + \frac{y'}{1 + r} - \left( t + \frac{t'}{1 + r} \right)
\]

Let \( T = t \) (assuming size of population equal 1, otherwise let \( T = N \cdot t \))

\[
t + \frac{t'}{1 + r} = G + \frac{G'}{1 + r}
\]

substituting in consumer lifetime budget

\[
c + \frac{c'}{1 + r} = y + \frac{y'}{1 + r} - \left( G + \frac{G'}{1 + r} \right)
\]

Note: if \( r \) is constant changes in \( t \) and \( t' \) don’t matter

**Ricardian Equivalence: In words**

Suppose the government today lowers \( T \) by 100$ and raises \( B \) by 100$

- If \( r = 3\% \), tomorrow the government owes 103$
  - taxes tomorrow go up by 103$.
- Household has two course of actions:
  1. Keep same spending on \( C \), today save 100$, tomorrow earn 103$ and use to pay increased taxes.
  2. Spend today the extra 100$, today save 0$, tomorrow lower consumption by 103$ to pay for taxes.
- What would the household do?
Ricardian Equivalence: Credit Markets

- Does $r$ change?
  - No: since demand and supply of assets cancels out
- Think about the previous example

Note: $S^P$ is private demand for saving

Ricardian Equivalence: Assumptions

1. Taxes are equal for all populations (no redistribution)
2. Debt repaid while you are alive
3. Lump sum taxes
4. Credit markets without frictions

Data on Interest Rates
Household Savings: Interest Rates

The closest parallel in data of the bond in our model is the: 3 month T-bill

The bond in the model has two special features:

1. It cannot be defaulted on
2. Is available in one maturity

In data...

Source: St. Louis Fed http://research.stlouisfed.org/fred2/series/WTB3MS
Slide 33 of 44

Bonds: Model vs Data

In data we have different maturities:

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Bonds: Maturity
Bonds: Maturity

- **Question:** how would the model price different maturities?

- **Answer:** let’s assume that by the time the bonds matures, the return is the same even if you had rolled over bonds of shorter maturities

Let \( r_m = \) return of bond of maturity \( m \)

\[
(1 + r_m)^m = (1 + r) \times \cdots \times (1 + r) \quad \text{m times}
\]

- Yield curve should be flat... what is missing?

---

Bonds: Default

In data we have bonds with different default risk:


**Question:** how would the model price different default risks?

**Answer:** let’s assume that the return on each bond is the same

(In finance you will study the **efficient market hypothesis**)

Let \( p_i = \)probability that country \( i \) defaults

\[
(1 - p_i) r_i = r \quad \text{return on bonds of} \ i \quad \text{return on US bonds}
\]
Comparative Statics

We look at the following cases:

1. Temporary changes in income: either today or tomorrow.
2. Permanent changes in income.
3. Changes in interest rate.

Comparative Statics: Change in Income

Increase in today’s income: $y_1 \Rightarrow y_2$ with $y_2 > y_1$

- Recall $we_i = y_i + \frac{y'}{1+r} - t - \frac{y'}{1+r}$
- Change in wealth: $\Delta we = (we_2 - we_1) = y_2 - y_1 > 0$
- So that: outward shift in budget constraint
  - Consumption increases today and tomorrow! (remember income effects)
• Don’t forget **consumption smoothing**!

![Graph showing percentage deviation from trend](source: Bureau of Economic Analysis, Department of Commerce)

• Our model of $C$ does not include durables, how would you model them?

**Comparative Statics: Change in Income**

• Suppose **permanent** increase in income $y_1 \Rightarrow y_2$ and $y'_1 \Rightarrow y'_2$

• In the picture optimal choice moves from $H \Rightarrow K$

![Graph illustrating optimal choice](source: Bureau of Economic Analysis, Department of Commerce)

• Difference with respect to temporary changes? Larger effect on consumption since savings may not increase
9.3 The Government
Deviation From Trend Consumption vs. GDP

From Lecture 3:

- Consumption is: slightly less variable

Two Period Model: Saving

Question: how much does a household save?

- Recall saving equals
  \[ s = y - t - c \]

- Using equation (1) the budget constraint is
  \[ c(2 + r) = y(1 + r) + y' + t(1 + r) + t' \]

So that

\[ s = \frac{(y - t)(2 + r) - [y(1 + r) + y' + t(1 + r) + t']}{2 + r} \]

\[ s = \frac{(y - t) - (y' - t')}{2 + r} \]
Federal Reserve provides all information on who saves where...

Household Balance-sheet: Flow of Funds

B.109 Balance Sheet of Households and Nonprofit Organizations (1)
Billion of dollars; amounts outstanding at end of period, not seasonally adjusted

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<td>48 Liabilities and net worth</td>
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<td>50 Other nonfinancial assets</td>
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<td>51 Total liabilities and net worth</td>
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</tbody>
</table>

Source: St. Louis Fed
http://research.stlouisfed.org/fred2/series/PSAERT/

Household Savings: Rates

Source: St. Louis Fed

International Rates

International Household Saving Ratios (quarterly)

Source: Organisation for Economic Co-operation and Development.

175 of 260
At a national level:

\[ S = S^p + S^g \]

National Saving = Private Saving + Government Saving

Source: http://research.stlouisfed.org/publications/net/page15.pdf

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9.4 Elastic Labor
EXTENDING THE TWO PERIOD MODEL

What is the two periods model missing so far?

1. Labor supply and wages
2. Firms
3. Investment decision

Consumption Today

Let consumption depend on wealth and interest rate: \( C(we, r) \)

Q: What happens when we change wealth and interest rates?

Effects on the consumption of goods:

- Demand of current consumption increases when \textbf{lifetime wealth} increases (consumption is a normal good)

\[
\frac{dC(we, r)}{dwe} > 0
\]

- Current consumption decreases with \textbf{interest rate} increases (we assume substitution effect dominates)

\[
\frac{dC(we, r)}{dr} < 0
\]
The Elastic Consumer

Up to now $y$ was exogenous $\Rightarrow$ now introduce elastic labor:

- Today budget constraint:
  
  $$c + s = w(h - l) + \pi - T$$

- Tomorrow budget constraint:
  
  $$c' = w'(h - l') + \pi' - T + (1 + r)s$$

- Lifetime budget constraint:
  
  $$c + \frac{c'}{1 + r} = w(h - l) + \pi - T + \frac{w'(h - l') + \pi' - T}{1 + r}$$

Optimality and Labor Supply

Optimality conditions:

- First period consumption-leisure trade-off: $MRS_{t,c} = w$

- Second period consumption-leisure trade-off: $MRS_{t',c'} = w'$

- Optimal consumption saving: $MRS_{c,c'} = 1 + r$

Interest Rates and Labor Supply

Let labor supply be $N(we, r, w)$. Effects on the supply of labor:

- Current labor supply is increasing in real wage
  
  (from now on assume substitution larger than income effect)
  
  $$\frac{dN(we, r, w)}{dw} > 0$$

- Current labor supply decreases if lifetime wealth increases
  
  $$\frac{dN(we, r, w)}{dwe} < 0$$

- Current labor supply increases when the interest rate increases
  
  $$\frac{dN(we, r, w)}{dr} > 0$$
9.5 The Firm
Adding Investment decision:

**Table 784. Capital Expenditures: 2000 to 2009**

(In billions of dollars (1,181 represents $1,181,000,000,000). Based on a sample survey and subject to sampling error; see source for details)

<table>
<thead>
<tr>
<th>Item</th>
<th>All companies</th>
<th>Companies with employees</th>
<th>Companies without employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital expenditures, total...</td>
<td>1,161 1,146 1,374 1,250</td>
<td>1,090 1,083 1,294 1,015</td>
<td>71 62 80 73</td>
</tr>
<tr>
<td>New</td>
<td>364 362 552 416</td>
<td>338 339 523 415</td>
<td>26 20 33 25</td>
</tr>
<tr>
<td>Used</td>
<td>35 36 39 27</td>
<td>30 31 33 26</td>
<td>6 8 10 8</td>
</tr>
<tr>
<td>Equipment and software</td>
<td>751 701 765 607</td>
<td>718 665 728 577</td>
<td>32 37 37 30</td>
</tr>
<tr>
<td>New</td>
<td>46 42 47 35</td>
<td>34 29 37 25</td>
<td>12 13 10 10</td>
</tr>
<tr>
<td>Used</td>
<td></td>
<td></td>
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<tr>
<td>Capital leases</td>
<td>20 18 20 17</td>
<td>19 19 19 17</td>
<td>22 12 1</td>
</tr>
</tbody>
</table>

Z Less than $500 million.

- Source US Census: LINK

**Online Survey!**

Q: WHICH INDUSTRY DOES THE BULK OF INVESTMENT?

A: YOUR answer here: HTTP://TINYURL.COM/73240-ALES

1. MINING
2. FORESTRY AND AGRICULTURAL SERVICES
3. MANUFACTURING
4. FINANCE AND INSURANCE
5. HEALTH CARE
Q: who does the bulk of investment?

Table 785. Capital Expenditures by Industry: 2000 and 2009

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Professional, scientific, and technical services</td>
<td>113-115</td>
<td>2</td>
<td>1</td>
<td>Management of companies and enterprises</td>
<td>23</td>
<td>102</td>
<td>61</td>
</tr>
<tr>
<td>Utilities</td>
<td>22</td>
<td>30</td>
<td>25</td>
<td>Administrative support services and administration</td>
<td>22</td>
<td>41</td>
<td>34</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>31-33</td>
<td>256</td>
<td>215</td>
<td>Health care and social assistance</td>
<td>22</td>
<td>79</td>
<td>60</td>
</tr>
<tr>
<td>Durable goods</td>
<td>321, 322, 323</td>
<td>134</td>
<td>77</td>
<td>Educational services</td>
<td>23</td>
<td>79</td>
<td>60</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>45</td>
<td>116</td>
<td>132</td>
<td>Arts, entertainment, and recreation</td>
<td>22</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>48-49</td>
<td>58</td>
<td>70</td>
<td>Accommodation and food services</td>
<td>72</td>
<td>28</td>
<td>26</td>
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<tr>
<td>Information</td>
<td>51</td>
<td>100</td>
<td>134</td>
<td>Other services (except public)</td>
<td>72</td>
<td>28</td>
<td>26</td>
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<tr>
<td>Finance and insurance</td>
<td>52</td>
<td>102</td>
<td>102</td>
<td>Structure and equipment expenditures</td>
<td>72</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Real estate and rental and leasing</td>
<td>53</td>
<td>73</td>
<td>92</td>
<td>Serving multiple industry categories</td>
<td>80</td>
<td>2</td>
<td>3</td>
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</tbody>
</table>


- Source US Census: LINK

The Firm

- Introduce non linear technology and investment decision
  - Output today: \( Y = zF(K, N) \)
  - Output tomorrow: \( Y' = z'F(K', N') \)

- Firm invests \( I \) so that
  \[
  K' = (1 - d)K + I
  \]

- Note: we are modeling \( K \) as in Solow.

The Firm

- Firm maximize present discounted value of the firm
  \[
  V = \pi + \frac{\pi'}{1 + r}
  \]

- Profits today: \( \pi = Y - wN - I \)

- Profits tomorrow: \( \pi' = Y' - w'N' + (1 - d)K' \)

- Note that now the firm owns the capital and liquidates it in the last period

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The Firm and Labor Demand

- Optimality $MP_N = w$ (wage goes up labor demand goes down)
- If $z$ or $K$ increase $\rightarrow$ labor demand increases. Why?

![Graph showing labor demand and wage relationship]

The Firm and Investment Decision

We now calculate the optimal investment decision.

The problem of the Firm is:

$$\max_{N,N',I} zF(K, N) - wN - I + \frac{z'F(K', N') - w'N' + (1-d)K'}{1+r}$$

Optimality with respect to $I$ gives

$$-1 + \frac{z'F_K((1-d)K + I, N) + (1-d)}{1+r} = 0$$

so that

$$\underbrace{z'F_K(K', N')}_{MP_K} - d = r$$

(net marginal product of capital tomorrow = interest rate)

The Firm and Investment Decision

- Suppose $r_1 \downarrow r_2$, since

  $$z'F_K((1-d)K + I_1) - d = r_1$$

  then investment increases $I_1 \uparrow I_2$

  (marginal benefit goes down)

![Graph showing investment decision and interest rate]
- If $z'$ tomorrow increases or if $K$ decreases, investment curve shifts to the right (marginal benefit increases since $MP'_K$ increases)

Suppose that the production function is Cobb-Douglas:

$$zF(K, N) = zK^\alpha N^{1-\alpha}$$

Then optimality implies

$$z'\alpha \left( \frac{K'}{N'} \right)^{\alpha-1} = r + d$$

substituting $K' = (1 - d)K + I$ we get

$$I = \left[ \frac{z'\alpha}{r+d} \right]^{\frac{1}{1-\alpha}} N' - (1 - d)K$$

Note that $I$ is increasing in $z'$ and decreasing in $r$ and $K$. 
9.6 Equilibrium
Plan for This Lecture

1. Equilibrium in the complete two period model
   - The output supply curve
   - The output demand curve

2. Experiments/ Policy
   1. Change in government expenditures
   2. Production shocks:
      - Change in productivity
      - Change in capital stock

---

**Equilibrium in the complete two period model**

---

**Competitive Equilibrium: Dynamic**

- Definition of equilibrium expands what we have done in Lecture 5.

**Definition (Competitive Equilibrium)**

For a set of exogenous variables \((K, G, G', z, z')\) A competitive equilibrium is a set of endogenous variables \((C, N^s, S, I, N^d, B, T, Y, r, w)\) for both today (without prime) and tomorrow (with prime), so that:

1. The consumer chooses consumption, savings and labor supply optimally, taking as given wages, interest rate, taxes and dividends.

2. The firm chooses labor demand and investment to maximize profits, taking as given wages, interest rate and current/future productivity.

---

ES Turn to next page...
Competitive Equilibrium: Dynamic

Definition (Competitive Equilibrium (continued))

[...] continued:

3. Government balances the budget ($B$ is borrowing):
   \[ G = T + B; \quad G' + (1 + r)B = T' \]

4. Labor market clears: \( N^d = N^s; \quad N'^d = N'^s \)

5. Goods market clears: \( Y = C + I + G \quad Y' = C' + I' + G' \)

6. Financial market clears: \( B = S \)

Equilibrium: 2 Markets

- Analytical or graphical characterization of equilibrium is hard.
- We focus on the equilibrium of two markets:
  1. Today’s labor market (relating wages and employment)
  2. Today’s goods market (relating interest rate and output)

Which markets are we NOT focusing on?

Equilibrium in the Labor Market

We equate demand for labor (firm) and supply of labor (household):

- We determine employment level: \( N^* \)
- We determine wage rate: \( w^* \)
- !! supply of labor depends on \( r^* \)
We equate demand of goods \((Y^d)\) and supply of goods \((Y^s)\), where:

\[
Y^s = zF(K, N^s)
\]
\[
Y^d = C(we, r) + I(r) + G
\]

Goal: determine the relationship between \(Y^s\), \(Y^d\) and \(r\)

The Output Supply Curve

- \(Y^s\) as a function of \(r\) is called output supply curve.
- How does \(Y^s\) vary with respect to \(r\)? Recall that \(N^s(we, r, w)\)

\[
\frac{dY^s}{dr} = \frac{d}{dr}zF(K, N^s) = zF_N(K, N^s) \frac{dN^s}{dr} > 0
\]

\(Y^s\) is an increasing (and concave) function of \(r\)

The Output Demand Curve

- \(Y^d\) as a function of \(r\) is called output demand curve.

\[
Y^d(r) = C(we, r) + I(r) + G
\]

- Changing \(r\):

\[
\frac{dY^d}{dr} = \frac{dC(we, r)}{dr} + \frac{dI(r)}{dr} < 0
\]

\(Y^s\) is a decreasing (and concave) function of \(r\)
Graphing together demand and supply:

- We determine output level: $Y^*$
- We determine interest rate: $r^*$

Graphical Equilibrium

- Combining with the labor market equilibrium graph:

2 Questions

1. On March 11, 2011, Japan was hit by a massive earthquake.
   What do you forecast will happen to GDP, wages, employment, investment, interest rates?

   What do you forecast will happen to GDP, wages, employment, investment, interest rates?
Q: Suppose the government increases spending (G) by a dollar by how much does GDP (Y) change?

A: Your answer here: http://tinyurl.com/73240-ales

1. Between 0 and $0.5
2. Between $0.5 and $1
3. Between $1 and $2
4. More than $2

---

**SHIFTING OUTPUT CURVES**

---

**Shifting the Output Supply Curve**

Questions:

- How does output supply change following a change in $G$?
  1. If $G \uparrow$ then $T \uparrow$ so we ↓
  2. If we ↓ then $N^s \uparrow$
  3. So $zF(K, N^s) \uparrow$, Supply curve shifts to the right!

- How does output supply change following a change in $z$?
  1. If $z \uparrow$ then $zF(K, N) \uparrow$
  2. If $zF(K, N) \uparrow$ then $N^d \uparrow$
  3. Supply curve shifts to the right!

- Note: these are exogenous changes, not changes due to $r$ or $w$
Shifting the Output Supply Curve: Graphically

• Suppose TFP increases $z_1 \uparrow z_2$

Shifting the Demand Curve

• A change in output demand is due to a change in one of it’s components:

$$\Delta Y^d \propto \Delta C + \Delta I + \Delta G$$

• $G$ is exogenous but $C$ and $I$ are endogenous

• We need to look closer at what exogenous change impacts $C$ and $I$

Shifting the Output Demand Curve

Impacting $C$ and $I$:

1. decrease in present value of taxes: $\rightarrow C \uparrow$
2. increase in future income: $\rightarrow C \uparrow$
3. increase in future TFP: $\rightarrow I \uparrow$
4. decrease in the capital stock: $\rightarrow I \uparrow$

Each of these either affects $C$, or $I$. Also:

these are exogenous changes, not changes due to $r$ or $w$
• Quantitatively, how much does $Y^d$ change due to a change in environment?

• Key difficulty changes in $Y$ affect income which affects the wealth of the worker.

• So what happens if the household become wealthier? (for example with higher labor income)

  more demand for $C \rightarrow$ more demand for output $\rightarrow$
  $\rightarrow$ more labor income $\rightarrow$ even more demand for $C \ldots$

---

**MPC (Marginal Propensity to Consume)** defined as:

*The rate at which consumption increases when (disposable) income is increased by a small amount*

• Formally:

$$\frac{dC}{dwe} = MPC \cdot \Delta we$$

Note that in general $0 < MPC < 1$

---

**Average Propensity to Consume**

• Average propensity to Consume is $AMPC = \frac{\text{consumption}}{\text{disposable income}}$

It can be shown that $AMPC > MPC$

---

Taken from: Hoover (2011)
• The additional “wealth” effect of an increase in Y is:

\[
\frac{dC}{d\text{we}} = \text{MPC} \cdot \frac{\Delta Y^d}{\text{change in wealth}}
\]

• Introduce the indirect increase in \( C \) following a increase in \( Y \)

\[
\Delta Y^d = \text{Wealth effect} + \text{Additional change} = \text{MPC} \cdot \Delta Y^d + \Delta C + \Delta I + \Delta G = \frac{1}{1 - \text{MPC}} (\Delta C + \Delta I + \Delta G)
\]

• The multiplier since “multiplies” changes in demand, captures the overall income effect. Note that the multiplier is greater than 1.

Experiments

We next go over the following examples studying equilibrium changes:

1. Temporary Increase in G
2. Increase in TFP today
3. Decrease In Capital Stock
4. Increase in TFP tomorrow
5. Permanent Increase In G
To solve these exercises follow these steps:

1) Identify effect of change on consumer, government, firm (these are exogenous changes, not changes due to \( r \) or \( w \))
2) Identify first tentative equilibrium in labor market
3) Identify effect on output supply curve
4) Identify effect on output demand curve
5) Determine changes in \( Y \) and \( r \) in the goods market.
6) Using result in 2) and change in \( r \) determine change in \( N \) and \( w \)
7) In 5) and 6), specify which result are determinate and which are indeterminate

**Government Expenditure in Equilibrium**

Suppose government increases expenditures \( \Delta G > 0 \):

1) \( \Delta N^s > 0 \), why?
2) Output supply shifts to the right
3) Output demand (start from key formula):
   \[
   \Delta Y^d = \frac{1}{1 - MPC} (\Delta C + \Delta G + \Delta I)
   \]

   \( \Delta G > 0, \Delta I = 0 \) also \( \Delta C = \frac{dC}{dw} = MPC \cdot (-\Delta G) \)

   Effect of taxes

4) So that:
   \[
   \Delta Y^d = \frac{(-MPC \cdot \Delta G + \Delta G)}{1 - MPC} = \Delta G > 0
   \]

**Increase in G: graphical summary**

- Note that if \( Y^s \) shift “a little” \( \rightarrow r \) increases

![Graphical Summary](image-url)
Increase in G: summary

The effect of a stimulus:

- $C$ goes down (government is crowding out private consumption)
- $N$ and $Y$ go up
- $w$ goes down
- $r$ goes up
- Important: $\Delta Y < \Delta G$
  (Government multiplier < 1, for every dollar spent GDP goes up by less than a dollar)

Government Spending and GDP

- Question: what is the relation between $G$ and $Y$ in the data?
- Answer: no consensus among economist
  - Our theory predicts a government multiplier < 1
  - Keynesian analysis is based on a government multiplier > 1

For a quick summary look at this discussion between Boldrin - DeLong starting at 42:20
http://tinyurl.com/BoldrinDelong

Table 2

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<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtrts</th>
<th>12 qts</th>
<th>20 qts</th>
<th>Maximum</th>
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<td>DEFICIT FINANCED TAX CUT</td>
<td>0.20</td>
<td>0.53</td>
<td>2.08</td>
<td>6.19</td>
<td>3.30</td>
<td>9.59 (qtr 14)</td>
</tr>
<tr>
<td>DEFICIT SPENDING</td>
<td>0.44</td>
<td>0.31</td>
<td>0.37</td>
<td>0.29</td>
<td>0.33</td>
<td>0.44 (qtr 1)</td>
</tr>
</tbody>
</table>

This table shows the present value multipliers for a deficit financed tax cut policy shock and for a deficit spending fiscal policy shock. The multipliers given are the median multipliers in both cases.

Taken from: Mountford and Uhlig (2005)
When does government spending have an effect?

<table>
<thead>
<tr>
<th>Fiscal Shock</th>
<th>Maximum Multiplier</th>
<th>Minimum Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median Multiplier</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>Deficit Spending</td>
<td>1.36</td>
<td>0.75, 1.59</td>
</tr>
<tr>
<td></td>
<td>lag 9</td>
<td>lag 1, lag 24</td>
</tr>
<tr>
<td>Balanced Budget</td>
<td>0.45</td>
<td>0.18, 1.59</td>
</tr>
<tr>
<td></td>
<td>lag 3</td>
<td>lag 1, lag 24</td>
</tr>
<tr>
<td>Tax Cut</td>
<td>3.45</td>
<td>3.11, 4.65</td>
</tr>
<tr>
<td></td>
<td>lag 13</td>
<td>lag 9, lag 14</td>
</tr>
</tbody>
</table>

These statistics relate to the distribution of the maximum and minimum impact multiplier effects of each fiscal shock. For each draw the maximum and minimum fiscal multiplier is calculated and the 16th, 50th and 84th percentiles of these results are displayed. The multiplier statistic is calculated in terms of the initial, lag 0, fiscal shock as follows:

$$\text{Multiplier for GDP} = \frac{\text{GDP response}}{\text{Fiscal shock at Lag 0}} \times \frac{1}{\text{Average Fiscal variable share of GDP}}$$

and minimum multipliers of the two spending shocks in the first year after the shock. In this case we now get the result that the deficit spending shock’s minimum multiplier is insignificantly different from zero but that for the balanced budget spending shock is still significantly negative.

4.8 Policy Conclusions

An important lesson one can draw from the results is that while a deficit-financed expenditure stimulus is possible, the eventual costs are likely to be much higher than the immediate benefits. For suppose that government spending is increased by two percent, financed by increasing the deficit: this results, using the median values from Table 5,

19

Taken from: Mountford and Uhlig (2005)

Change in Productivity

Suppose TFP today increases: $\Delta z > 0$

1) $\Delta N^d > 0$, why? marginal product of labor increases
2) Output supply shifts to the right (higher $z$ and $N$)
3) Output demand: $\Delta C = 0$, $\Delta I = 0$, $\Delta G = 0$. So that

$$\Delta Y^d = \frac{1}{1 - MP^C} (\Delta C + \Delta G + \Delta I) = 0$$

No shift!
Don’t forget affect of $r_2$ on labor supply

Summarizing:
- Output supply shift to the right $\rightarrow$ lowers $r$
- This causes labor supply to shift to the left

In equilibrium:
- Effect on $N$ ambiguous (most likely increasing); $w$ increases
- $Y$ increases and $r$ decreases

Changes in $z$ can be used to model US economy Cycles

Taken from: Kydland and Prescott (1982)
Suppose capital stock today decreases: $K \downarrow$

1) Labor demand shifts to the left (why?)

2) Output supply shifts to the left

3) Output demand: $\Delta I > 0$. Output demand shift to the right. (Firm increases investment since $K$ decreased)

4) Increase in $r$ makes labor supply shift to the right

Summarizing in equilibrium:

- $I$ increases
- $Y$ ambiguous, $r$ goes up
- $w$ decreases; $N$ ambiguous (most likely down)
The peculiarity of the next two examples is that GDP tomorrow will change.

In solving for equilibrium it will be important to understand how the household will anticipate future income changes.
• Suppose that $z'$ goes up
• No change (for now) in current labor market or labor supply
• Recall:

$$\Delta Y^d = \frac{1}{1 - MPC} (\Delta C + \Delta G + \Delta I)$$

$\Delta I > 0$ firm anticipate higher return to capital tomorrow
$\Delta C = MPC \cdot \Delta Y' > 0$
• Interest rate go up
• Labor supply shifts to the right

Punchline:
• $C$ might go up if income effects due to future income increase dominate substitution effect due to higher $r$
• $I$ goes up
• $N$ and $Y$ go up
• $r$ goes up
• $w$ goes down
Permanent Increase in G

- We model permanent changes as changes to \( G \) and \( G' \) (suppose both go up by \( \Delta G \))

- When \( G \) and \( G' \) increase it implies \( T \) or \( T' \) prime go up. Change in NPV of taxes

\[
\Delta(taxes) = \Delta G + \frac{\Delta G}{1 + r}
\]

\( \Rightarrow \) Labor Supply and Output Supply shift to the right

Permanent Increase in G

- Recall:

\[
\Delta Y^d = \frac{1}{1 - MPC} (\Delta C + \Delta G + \Delta I)
\]

and \( \Delta C = MPC \cdot \Delta(\text{income}) \)

- The tricky shift is on the output demand curve; two effects on income

  1) increase in NPV taxes: \( \Delta G + \frac{\Delta G}{1 + r} \)

  2) changes in income: \( \Delta Y'/(1 + r) \)

Permanent Increase in G

\[
\Delta Y^d = \frac{MPC \left[ \frac{\Delta Y'}{1 + r} - \Delta G - \frac{\Delta G}{1 + r} \right] + \Delta G + \Delta I}{1 - MPC}
\]

- Permanent changes imply same changes today and tomorrow \( \Rightarrow \) no changes in saving of the household

- If \( r \) does not change \( \Rightarrow \) no changes in investment, so that: \( \Delta I = 0 \) and \( \Delta Y' = \Delta G \)

\[
\Delta Y^d = \Delta G
\]
Permanent Increase in G

- Q: Does $r$ change?
- A: NO

Punchline:
- $C$ unchanged
- $I$ unchanged
- $N$ and $Y$ go up
- $r$ unchanged
- $w$ goes down
- Important: $\Delta Y = \Delta G$
  
  (Government multiplier = 1)
Chapter 10

Credit Imperfections
Online Survey!

Q: In your opinion what is the biggest shortcoming in our modeling of credit markets?

A: Your answer here: http://tinyurl.com/73240-ales

1. Lack of collateral for loans
2. Lack of default and bankruptcy
3. Lack of financial panics
4. Lack of bid/ask spreads
5. Lack of bank failures

Plan for This lecture

1. Financial Imperfections: Asymmetric information
   - Effect on Spreads
   - Effect on Ricardian Equivalence
2. Financial Imperfections: Limited Commitment
   - Collateral
3. Panics and Bank Runs

Credit Market Imperfections
Credit Market Imperfections

How do real credit markets compare to what we have studied?

- Borrowing and lending at different rates
  - Different rates for different borrowers
- Limits on the quantity borrowed
  - Collateral requirements for loans

**Definition**

**Credit Imperfection:** Any type of obstacle, either technological or institutional that prevents an optimal level of trade in the credit market.

We will look into two types of credit market imperfections:

- Asymmetric information
- Limited commitment

---

**Asymmetric Information**

- We have **asymmetric information** when some market participants know more about own characteristics than other participants.

- In the credit market: a borrower knows more about his or her own credit worthiness than do potential borrowers.

- Why does it matter?
  - A lender cannot differentiate between good and bad borrowers.

---

**Asymmetric Information: Implications**

- If lender cannot distinguish between good and bad borrowers:
  - Lending is more risky (some borrowers will default)
  - Different rates at which consumers can borrow and lend

- Suppose that: **good borrowers, repay; bad, do not.**
  - $0 < a < 1$: fraction of good borrowers
  - $1 - a$: fraction of bad borrowers

- Suppose that a measure 1 of savers saves (deposits) amount $L$
Banks, Lenders, Borrowers

Banks:
• Issues loans at interest rate $r_L$
• Pays interest $r_D$ on deposit
• Diversify by lending to a large number of borrowers
  → a fraction of borrowers $a$ will not default, $1 - a$ will default

Good borrowers:
• Choose the same loan quantity $L$

Bad borrowers:
• Mimic good borrowers and choose loan quantity $L$

Banks: Default Premium

Profit of banks:
$$\pi = aL(1 + r_L) + (1 - a)L \times 0 - L(1 + r_D)$$

In equilibrium each bank makes 0 profits $\Rightarrow \pi = 0$. So that
$$aL(1 + r_L) = L(1 + r_D)$$

Equilibrium interest rate on a loan:
$$r_L = \frac{1 + r_D}{a} - 1$$

Each borrower pays a default premium on a loan
• Premium is equal to the difference $r_L - r_D$
• It grows as the fraction of bad borrowers increases

Interest rate spreads during the Financial crisis

• A credit spread is the difference in interest rate between two different loans.

Source: St. Louis Fed
http://research.stlouisfed.org/fred2/categories/119
Asymmetric Information and Ricardian Equivalence

- To prove Ricardian Equivalence we require perfect credit markets.
  - Ricardian equivalence fails in the presence of asymmetric information

- Use our basic inter-temporal model
  - consumer has income $y$ and $y'$ in periods 0 and 1
  - consumption of $c$ and $c'$ in periods 0 and 1
  - saving denoted by $s = y - c$

- Consumer lends at the interest rate $r_1$ and borrows at rate $r_2$, with $r_1 < r_2$

The Inter-temporal Budget Constraint

Budget constraint: $AEF$.

Households that picks to the right of $E$ are “credit constrained”: they would like to borrow more if rate was $r_1$. 
Suppose that:

- Key assumption:
  - the interest rate on government debt is the lending rate $r_1$

- There is a tax cut in the current period $\Delta t < 0$

- A tax increase in the second period $-\Delta t(1 + r_1)$

Change in timing of taxes shifts the endowment point

In the figure consumes new endowment point $E_2$

Consumption today increase by the amount of the tax cut

Ricardian equivalence fails!
Credit markets and Limited Commitment

- A loan is a promise to pay in the future.
- In the future, the borrower may decide to not keep his promise.
- Whenever a borrower cannot commit to repay we have a credit imperfection: Limited Commitment.
- With limited commitment, lender needs to set up contracts such that borrower has the incentive to pay.
  - One possible incentive device: require collateral

**Definition**

**Collateral:** An asset owned by the borrower that the lender has a right to seize if the borrower defaults on the loan.

Housing as collateral

- Suppose household owns a house of value $H$:
  - Value of the house is $p \cdot H$. Where $p$ is the housing price level
  - House are illiquid assets. Cannot be sold quickly to finance current consumption
- Consumer’s lifetime wealth:
  $$we = y - t + \frac{y' - t' + p \cdot H}{1 + r}$$
- Note: wealth depends on $p$
- Suppose household uses $H$ as a collateral

Banks and Housing

- Let: $c + s = y - t$
- Using $H$ as collateral, banks offer loan $s$ so that: the amount borrowed $s$ by the consumer must satisfy:
  $$s(1 + r) \geq \frac{-p \cdot H}{1 + r}$$
  this inequality is called the “collateral constraint”
- Since $c = y - t - s$, we have
  $$c \leq y - t + \frac{p \cdot H}{1 + r}$$
  consumption depends on value of collateral!
• The budget constraint with a collateral constraint:

![Graph showing budget constraint with collateral constraint]

• Consumption today and tomorrow is impacted by $p$

Consumption and Collateral Constraints
What happened to the valued of housing from 2007 onwards?

![Graph showing change in housing value from 2007 to 2014]

Source: http://research.stlouisfed.org/fred2/series/SPCS20RSA?rid=199

Financial Intemidiation
**Definition**

**Share of Private Credit:** Value of credit by financial intermediations to the private sector divided by GDP.

Fig. 3: Partial scatter plot of growth vs. private credit.

Source: Levine, Loayza, Beck (2000)

---

**What is Happening?**

- September 2007:

---

- March 2014:

Source: [http://www.reuters.com/article/slideshow/idUSBREA2P02H20140326#a=2](http://www.reuters.com/article/slideshow/idUSBREA2P02H20140326#a=2)
Financial Intermediation

- Up to this point in the course we have abstracted from financial intermediation.

- The previous models of private information and limited commitment introduce the concept of an intermediary: a bank.

- There is substantial evidence linking growth to the “maturity” of the financial sector.

Given this let’s have a close look at the benefits and costs of bank as financial intermediary.

Banks as Intermediaries

- What do Bank-like intermediaries do:
  1. They borrow from one group of agents and lend to another group of agents.
  2. The borrowing and lending groups are large, suggesting diversification on each side of the balance sheet.
  3. The structure of the bank loans does not mirror the banks obligations in the form of deposits.

Source: Gorton, Winton
http://fic.wharton.upenn.edu/fic/papers/02/0228.pdf

Banks as Intermediaries

- Why do banks exist?
  1. They are delegated monitors:
     Banks monitor borrowers; given comparative advantage is natural to have one agent specializing in it.
  2. They generate information:
     By searching and allocating loans banks provide signals to other investors.
  3. They provide insurance to consumers:
     Providing loans helps consumer smooth consumption over time.
• Model of banking studied by Diamond and Dybvig

• Written to explain bank runs (could also be applied to financial panics)

• Basic idea: depositors/investors play a coordination game:
  1. With good coordination no problem for the bank;
  2. With bad coordination bank fails.

• Note: failure can occur without fundamental problems with the bank.

The model

• Bank offer deposits:
  • Short term \( \rightarrow \) return \( R_s \)
  • Long term \( \rightarrow \) return \( R_l \) \((R_l > R_s)\)

• Investors/Depositors have need for liquidity either:
  • In the short term \((1/2 \text{ of the population})\)
  • In the long term \((1/2 \text{ of the population})\)

• Bank is aware of the need for liquidity and invests accordingly:
  \( \rightarrow \) Bank has half it’s asset in short securities half in long securities

The problem:

• Depositors can withdraw at any time (even if they do not need liquidity)

• Banks has half of it’s asset in short securities.
  If every agent withdraws at the same time the bank FAILS!
• Decision to withdraw for long term investors depends on their beliefs of what others do:
  
  • If they believe other investors are not withdrawing the best decision is to wait for the long run and cash higher return $R_l$
  
  • If they believe other investors are withdrawing the is best to run to the bank and withdraw now!
  
  • Why run? they believe (and are correct) that the bank will fail.

Intermediation: Diamond - Dybvig

• Model as a 2 person game between myself and others:

Table : Payoffs from a Diamond Dybvig game

<table>
<thead>
<tr>
<th>Me - Others</th>
<th>Run</th>
<th>Don’t Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>$\frac{1}{2}R_s$</td>
<td>$R_s$</td>
</tr>
<tr>
<td>Don’t Run</td>
<td>0</td>
<td>$R_l$</td>
</tr>
</tbody>
</table>

• The game has two Nash equilibria:
  
  1. No panic: Don’t run / Don’t run
  2. Panic: Run/ Run

Suspension of Convertibility

• The fundamental issue is that:
  
  1. Liquidity needs are non-observable/non-contractable.
  2. Consumers reach the bank 1 by 1: a sequential service constraint.
  3. A solution to the problem of runs can be simple: the bank can simply close. This is usually referred to suspending convertibility.
  4. Suspending convertibility is costly for consumers who need liquidity.

• Is there a better solution? YES
• Federal Deposit Insurance Corporation signed into law in the Banking Act of 1933.

• Simply: It provided a Federal guarantee to bank deposits.

• Nine banks failed in 1934, compared to more than 9,000 in the preceding four years.

• Today: FDIC insurance covers all deposit accounts, including checking and savings accounts, money market deposit accounts and certificates of deposit. The standard insurance amount is $250,000 per depositor, per insured bank, for each account.


Intermediation: Diamond - Dybvig

• How does the FDIC work in the DD framework?

Table: Payoffs from a DD game with FDIC

<table>
<thead>
<tr>
<th>Me - Others</th>
<th>Run</th>
<th>Don’t Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>$R_s$</td>
<td>$R_s$</td>
</tr>
<tr>
<td>Don’t Run</td>
<td>$R_l$</td>
<td>$R_l$</td>
</tr>
</tbody>
</table>

• Q: In the model described, how much does the FDIC pay out?

Deposit Insurance Across Countries

Source: Kunt, Karacaoglu, Laeven (2005).
Chapter 11

Money
Money

1. Money aggregates
   - Real and nominal interest rates

2. Monetary model
   - The consumers, firms and government using money
   - Money Demand, effects of money

3. The Federal Reserve
   - History and Structure
   - Changing money supply

4. Simple monetary policy
   - Inflation Targeting
   - Interest Rate Targeting

Three questions:

1. What is money?
   - A medium of exchange
   - A store of value
   - A unit of account

2. Why does money matter?

3. Why do people hold money?
Measuring the money supply

Federal Reserve issues 3 measure of monetary aggregates:

M0: Liabilities of the Federal Reserve: currency
M1: M0 + travelers checks + demand deposits
M2: M1 + savings deposits + money market mutual funds

Table: Billions of Dollars. Data April 7, 2014

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>2,754.2</td>
</tr>
<tr>
<td>Currency</td>
<td>1,196.9</td>
</tr>
<tr>
<td>Travelers’ checks</td>
<td>3.3</td>
</tr>
<tr>
<td>Demand deposits</td>
<td>1,079.3</td>
</tr>
<tr>
<td>Other checkable deposits</td>
<td>474.6</td>
</tr>
<tr>
<td>M2</td>
<td>11,194.0</td>
</tr>
<tr>
<td>Savings deposits</td>
<td>7,269.9</td>
</tr>
<tr>
<td>Time deposits</td>
<td>528.6</td>
</tr>
<tr>
<td>Money market mutual funds</td>
<td>641.3</td>
</tr>
</tbody>
</table>


Who Holds The Cash?

- In 2012, U.S. currency averaged about $2800 per person
- Surveys show U.S. HH only hold about $100
- Some is held by businesses and the underground economy (another $200/300)
- The rest is held abroad!

Changes in Money Supply

- Federal Reserve controls the money supply

Source: [http://research.stlouisfed.org/fred2/categories/29](http://research.stlouisfed.org/fred2/categories/29)
Changes in Money Supply

- What does it effect?

- Strong relation between Money Supply and Prices.

- This introduces a relation between Money Supply and return on a bond.

The Return on a Bond

We focus on risk-less bonds:

- A nominal Bond is an asset that sells for one unit of dollars today and returns $1 + R$ dollars tomorrow.

- The nominal return is $R$, what is the real return?

- Recall the inflation rate $i = \frac{P' - P}{P}$
  $(P$ is the price level today, $P'$ tomorrow)

- The real return $r$ is given by the Fisher equation:

$$1 + r = \frac{1 + R}{1 + i}$$

- For small inflation rates, approximate to $r \approx R - i$

Appendix: Deriving The Fisher Equation

- Real cost today: $\frac{1}{P}$

- Real return tomorrow: $\frac{1 + R}{P'}$

- Real return:

$$1 + r = \frac{1 + R}{P} \cdot \frac{1}{P'} = \frac{1 + R}{P'} = \frac{1 + R}{1 + i}$$
Nominal Returns and Inflation

Comparing the nominal returns on a 1 Year T-bill and inflation:

[Graph showing the comparison between consumer price index and 1-Year Treasury Bill/Secondary Market Rate (TBillR)].

Shaded areas indicate US recessions.

2014 research.stlouisfed.org

Slide 12 of 47
11.1 Monetary model
A Monetary Model

- We want to build a model where Household and Firms use money.

- Let’s look at real return on money \( r_m \):

\[
1 + r_m = \frac{1 + 0}{1 + \bar{i}} = \frac{1}{1 + \bar{i}}
\]

so \( r_m < r \), money always has lower real returns than other safe assets.

- A Puzzle: Why do households use money?

Models of Money

There are several way to introduce money in a model:

1. Money in the utility function
   (people hold money because they like too)
2. Money search
   (people need money to ease transactions)
3. Cash in advance model
   (people need money to finance consumption and investment)

A Monetary Model: Cash in Advance

Some new ingredients for our model:

1. Nominal prices of goods today (price level): \( P \)
2. Household:
   - needs cash to buy goods
   - uses bonds to save
3. Firms: need cash to pay for Investments
4. Government controls the quantity of money: \( M \)
The Government

- In the model Government is in charge of the Federal Reserve.
- Changes the money supply:
  \[ \Delta M = M' - M \]
- Budget constraint is:
  \[ P \cdot G + (1 + R) \cdot B = P \cdot T + B' + M' - M \]

**Question:**
Is there a problem if the government controls both \(B\) and \(M\)?

---

**Changing The Money Supply**

**Changing The Money Supply: Model/ Real Life**

- In the Model \(\rightarrow\) from the government budget constraint:
  \[ M' - M = P \cdot G - P \cdot T + (1 + R)B - B' \]

  Can change money supply with:
  1. Changes in \(T\): rebates
  2. Changes in \(B'\): open market operations
     (exchange of cash for debt)

- In the US and most economies \(\rightarrow\) money supply is controlled by a central bank (the Federal Reserve System in the US)

  Changes in the money supply are achieved with:
  1. Reserve Requirements (rare)
  2. Open Market operations
  3. Discount loans
1775-1791: US Currency in the Beginning
- Continental Congress prints paper money ("Continents") to finance the American Revolution.
- Over printing lead to high inflation and loss of faith in notes.

1791-1811: First Attempt at Central Banking
- Treasury Secretary Alexander Hamilton pushes Congress to establish the First Central Bank of the United States, headquartered in Philadelphia, in 1791.
- 1811 when the bank’s 20-year charter expired, Congress refused, by one vote, to renew it.

1836-1865: The Free Banking Era
- State-chartered banks and unchartered “free banks” took hold during this period, issuing their own notes, redeemable in gold.
- Beginning of modern banking: demand deposits, check transactions, clearinghouses...

1863: National Banking Act
- Nationally chartered banks, whose circulating notes had to be backed by US government securities.
- Amendment required taxation on state bank notes but not national bank notes, creating a uniform currency for the nation.

1873-1907: Financial Panics Prevail
- Regular bank runs and financial panics.
- 1893 a banking panic triggered the worst depression the United States had ever seen.

1913: The Federal Reserve System is Born
- Federal Reserve Act signed into law by President Wilson on December 23, 1913.
11.2 The Fed and Monetary Policy
Board of Governors:

- Seven members appointed by the President and confirmed by the Senate to 14-year terms of office.
- President designates, and the Congress confirms, two members of the Board to be Chairman and Vice Chairman for 4-year terms.
- The President by law selects a fair representation of the financial, agricultural, industrial, and commercial interests and geographical divisions of the country.

Federal Open Market Committee (FOMC):

- 12 members—the seven members of the Board of Governors of the Federal Reserve System; the president of the Federal Reserve Bank of New York; and four of the remaining eleven Reserve Bank presidents, who serve one-year terms on a rotating basis.
- Holds eight meetings per year. At these meetings, the Committee reviews economic and financial conditions, determines the appropriate stance of monetary policy, and assesses the risks to its long-run goals of price stability and sustainable economic growth.

http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm

FED and Banks Balance Sheet

- The Banks:

<table>
<thead>
<tr>
<th>Balance sheet of the Banking System</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSETS</td>
<td>LIABILITIES</td>
</tr>
<tr>
<td>US securities</td>
<td>Checkable Deposits</td>
</tr>
<tr>
<td>Reserves</td>
<td>Discount loans</td>
</tr>
<tr>
<td>Loans and Mortgages</td>
<td></td>
</tr>
</tbody>
</table>

- Definition:

  Reserves = Required Reserves + Excess Reserves
• The Fed:

**Balance sheet of the FED**

<table>
<thead>
<tr>
<th>ASSETS</th>
<th>LIABILITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>US securities</td>
<td>Currency in Circulation</td>
</tr>
<tr>
<td>Discount loans to banks</td>
<td>Reserves</td>
</tr>
</tbody>
</table>

**Definition:**

Monetary Base = Currency in Circulation + Reserves

**FED Balance Sheet**

Taken from: [http://www.clevelandfed.org/research/](http://www.clevelandfed.org/research/)

**Open Market Operations**

• For example the Fed buys 1$ in US securities from banks:

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>US securities +1$</td>
<td>Currency in Circulation</td>
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<td>Reserves +1$</td>
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<tr>
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<tr>
<td>US securities −1$</td>
<td>Checkable Deposits</td>
</tr>
<tr>
<td>Reserves +1$</td>
<td>Discount loans</td>
</tr>
</tbody>
</table>

• Monetary base increase by 1$

• Question: what if the T-bill is purchased from the Household?
Discount Loans

- For example: the Fed loans 1$ to banking system:
  http://tiny.cc/8RDgD

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>ASSETS</strong></td>
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<td>US securities</td>
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<tr>
<td>Discount loans to banks +1$</td>
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<tbody>
<tr>
<td><strong>ASSETS</strong></td>
</tr>
<tr>
<td>US securities</td>
</tr>
<tr>
<td>Reserves +1$</td>
</tr>
</tbody>
</table>

- Monetary base increase by 1$

Money Demand and Equilibrium

Equilibrium in the Monetary Model

Four markets must be in equilibrium:

1. Goods Market: $Y = C + I + G$

2. Labor Market: $N_s = N_d$

3. Credit Market: $B = S$

4. NEW! Money Market:

\[ \frac{M^d}{M^s} = 1 \]

Money Demand  Money Supply
• Money Supply is set by the Government/FED

• We need a money demand equation

• How is it derived?

  Lot’s of algebra...for this course let’s take it as given
• Since government supplies $M^s$ inelastically:

\[ M^d = PL(Y, r + i) \]

---

**Targeting Rules**

---

**Targeting rules**

• Central Banks use one of the following “rules” for monetary policy:

  1. **Inflation Targeting:**
     
     Set \( i = i^* \)

  2. **Nominal Interest Rate Targeting:**
     
     Set \( R = R^* \); Where \( R = r + i \)
• Recent FED behavior seems to target \( i^* = 2\% \) or 3% 

• Other central banks:

![Graphs showing inflation targeting]

---

**Interest Rate Targeting: Data**

- Taken from: [http://www.newyorkfed.org/charts/ff/](http://www.newyorkfed.org/charts/ff/)

---

**Targeting rules: Example**

- Recall \( M^d = P \cdot L(Y, r) \)
  - Function \( L \) is increasing in \( Y \)
  - Function \( L \) is decreasing in \( r \)

- Suppose \( Y \) increases and \( r \) decreases.

- This implies that money demand shifts outwards.

- How should policy respond?
• Suppose the central bank targets $i^* = 0$, so that $P_1 = P_2$.

• Money supply must shift outward.

• Interest rate targeting is similar in spirit but more complicated since both $r$ and $i$ are changing.

THE EFFECTS OF INFLATION

Changes in M and Real Variables

• Question: what is the long run effect on $C, Y, N$ of changes in money supply?
Changes in M and Real Variables: Long Run

- To answer this let's (for example) look at the budget constraint:

\[ P \cdot C + (1 + R) \cdot B + M' = P \cdot Y + B' + M \]

- Given long run focus \( i = 0 \) so that \( R = r \)
- Changes in level of \( M \) and \( M' \) are offset by changes in \( P \)
- The answer: is none!
- This result is called long run money neutrality.

Changes in M and Real Variables: Short Run

- Question: what is the effect on \( Y \) and \( N \) of changes in money supply in the short run?
- The answer depends on whether inflation is expected or not:
  - If inflation is expected \( \rightarrow \) output decreases
  - If inflation is unexpected \( \rightarrow \) output increases

Expected Inflation

- Suppose workers get paid today and can use wages only for next period consumption.
- From optimality of the household:

\[ MRS_{l,C'} = \frac{P \cdot w}{P'} = \frac{w}{i - 1} \]

Intuition:
- Higher wages \( \rightarrow \) higher incentive to work
- Higher inflation \( \rightarrow \) lower purchasing power next period = less incentive to work!

- Note: this case assumes the agent expects inflation \( (i) \).
• What if inflation is unexpected? \(\rightarrow\) Friedman-Lucas model

• Suppose wage is payed next period, so that nominal wage is \(P' \cdot w\).

• Suppose also that \(P' \cdot w\) (nominal wages) increases.

• Summary:
  1. Workers do not expect inflation.
  2. Nominal changes in wage are perceived as real changes in wage
     \((P = P' \text{ and } w \uparrow)\)
  3. Wages goes up so workers work more \(\rightarrow\) output increases.

• Question: how many times will workers be “surprised” by inflation?
11.3 What Economists Do
What Economists Do

Robert E. Lucas, Jr.

December 9, 1988

Economists have an image of practicality and worldliness not shared by physicists and poets. Some economists have earned this image. Others--myself and many of my colleagues here at Chicago--have not. I'm not sure whether you will take this as a confession or a boast, but we are basically story-tellers, creators of make-believe economic systems. Rather than try to explain what this story-telling activity is about and why I think it is a useful--even an essential--activity, I thought I would just tell you a story and let you make of it what you like.

My story has a point: I want to understand the connection between changes in the money supply and economic depressions. One way to demonstrate that I understand this connection--I think the only really convincing way--would be for me to engineer a depression in the United States by manipulating the U.S. money supply. I think I know how to do this, though I'm not absolutely sure, but a real virtue of the democratic system is that we do not look kindly on people who want to use our lives as a laboratory. So I will try to make my depression somewhere else.

The location I have in mind is an old-fashioned amusement park--roller coasters, fun house, hot dogs, the works. I am thinking of Kennywood Park in Pittsburgh, where I lived when my children were at the optimal age as amusement park companions - a beautiful, turn-of-the-century place on a bluff overlooking the Monongahela River. If you have not seen this particular park, substitute one with which you are familiar, as I want you to try to visualize how the experiment I am going to describe would actually work in practice.

Kennywood Park is a useful location for my purposes because it is an entirely independent monetary system. One cannot spend U.S. dollars inside the park. At the gate, visitors use U.S. dollars to purchase tickets and then enter the park and spend the tickets. Rides inside are priced at so many tickets per ride. Ride operators collect these tickets, and at the end of each day they are cashed in for dollars, like chips in a casino.
For obvious reasons, business in park fluctuates: Sundays are big days, July 4 is even bigger. On most concessions—I imagine each ride in the park to be independently operated—there is some flexibility: an extra person can be called in to help take tickets or to speed people getting on and off the ride, on short-notice if the day is unexpectedly big or with advanced notice if it is predictable. If business is disappointingly slow, an operator will let some of his help leave early. So “GNP” in the park (total tickets spent) and employment (the number of man hours worked) will fluctuate from one day to the next due to fluctuations in demand. Do we want to call a slow day—a Monday or a Tuesday, say—a depression? Surely not. By an economic depression we mean something that ought not to happen, something pathological, not normal seasonal or daily ups and downs.

This, I imagine, is how the park works. (I say “imagine” because I as just making most of this up as I go along.) Technically, Kennywood Park is a fixed exchange rate system, since its central bank—the cashier’s office at the gate—stands ready to exchange local currency—tickets—for foreign currency—US dollars—at a fixed rate.

In this economy, there is an obvious sense in which the number of tickets in circulation is economically irrelevant. No-one—customer or concessioner—really cares about the number of tickets per ride except insofar as these prices reflect U.S. dollars per ride. If the number of tickets per U.S. dollar were doubled from 10 to 20, and if the prices of all rides were doubled in terms of tickets—6 tickets per roller coaster ride instead of 3—and if everyone understood that these changes had occurred, it just would not make any important difference. Such a doubling of the money supply and of prices would amount to a 100 percent inflation in terms of local currency, but so what?

Yet I want to show you that changes in the quantity of money—in the number of tickets in circulation—have the capacity to induce depressions or booms in this economy (just as I think they do in reality). To do so, I want to imagine subjecting Kennywood Park to an entirely operational experiment. Think of renting the park from its owners for one Sunday, for suitable compensation, and taking over the functions of the cashier’s office. Neither the operators of concessions nor the customers are to be informed of this. Then, with no advance warning to anyone inside the park, and no communication to them as to what is going on, the cashiers are instructed for this one day to give 8 tickets per dollar instead of 10. What will happen?

We can imagine a variety of reactions. Some customers, discouraged or angry, will turn around and go home. Others, coming to the park with a dollar budget fixed by Mom, will just buy 80 percent of the tickets they would have bought otherwise. Still others will shell out 20 percent more dollars and behave as they would have in the...
absence of this change in “exchange rates”. I would have to know much more than I do about Kennywood Park patrons to judge how many would fall into each of these categories, but it is pretty clear that no-one will be induced to take more tickets than if the experiment had not taken place, many will buy fewer, and thus that the total number of tickets in circulation—the “money supply” of this amusement park economy—will take a drop below what it otherwise would have been on this Sunday.

Now hear does all of this look from the point of view of the operator of a ride or the guy selling hot dogs? Again, there will be a variety of reactions. In general, most operators will notice that the park seems kind of empty, for a Sunday, and that customers don’t seem to be spending like they usually do. More time is being spent on “freebies”, the river view or a walk through the gardens. Many operators take this personally. Those who were worried that their ride was becoming passe’ get additional confirmation. Those who thought they were just starting to become popular, and had had thoughts of adding some capacity, begin to wonder if they had perhaps become over-optimistic. On many concessions, the extra employees hired to deal with the expected Sunday crowd are sent home early. A gloomy, “depressed” mood settles in.

What I have done, in short, is to engineer a depression in the park. The reduction in the quantity of money has led to a reduction in real output and employment. And this depression is indeed a kind of pathology. Customers are arriving at the park, eager to spend and enjoy themselves, Concessioners are ready and waiting to serve them. By introducing a glitch into the park’s monetary system, we have prevented (not physically, but just as effectively) buyers and sellers from getting together to consummate mutually advantageous trades.

That is the end of my story. Rather than offer you some of my opinions about the nature and causes of depressions in the United States, I simply made a depression and let you watch it unfold. I hope you found it convincing on its own terms—that what I said would happen in the park as the result of my manipulations would in fact happen. If so, then you will agree that by increasing the number of tickets per dollar we could as easily have engineered a boom in the park. But we could not, clearly, engineer a boom Sunday after Sunday by this method. Our experiment worked only because our manipulations caught everyone by surprise. We could have avoided the depression by leaving things alone, but we could not use monetary manipulation to engineer a permanently higher level of prosperity in the park. The clarity with which these affects can be seen is the key advantage of operating in simplified, fictional worlds.

The disadvantage, it must be conceded, is that we are not really interested in understanding and preventing depressions in hypothetical amusement parks. We are in-
interested in our own, vastly more complicated society. To apply the knowledge we have gained about depressions in Kennywood Park, we must be willing to argue by analogy from what we know about one situation to what we would like to know about another, quite different situation. And, as we all know, the analogy that one person finds persuasive, his neighbor may well, find ridiculous.

Well, that is why honest people can disagree. I don’t know what one can do about it, except keep trying to tell better and better stories, to provide the raw material for better and more instructive analogies. How else can we free ourselves from the limits of historical experience so as to discover ways in which our society can operate better than it has in the past? In any case, that is what economists do. We are storytellers, operating much of the time in worlds of make believe. We do not find that the realm of imagination and ideas is an alternative to, or a retreat from, practical reality. On the contrary, it is the only way we have found to think seriously about reality.

In a way, there is nothing more to this method than maintaining the conviction (which I know you have after four years at Chicago) that imagination and ideas matter. I hope you can do this in the years that follow. It is fun and interesting and, really, there is no practical alternative.
Chapter 12

The End: 7 lessons from this course
Tools you have learned

Four “fronts”:

1 Theory: You know how to build equilibrium macro models:
   • Micro-foundations

2 Empirics: You know where to look for any type of Macro data:
   • Proficient in using aggregate datasets
   • Graphical analysis and basic statistics
   • Filtering: linear and Hodrick-Prescott

3 Forecasting: Do you know what unemployment will be on Friday?

4 Quantitative: You know how to map models to data:
   • Calibration: factor shares, TFP, disutility from labor, capital stock
   • Effect of taxes on hours; Optimal Taxation

7 Lessons to remember

1 In data households and firms display dynamic and forward looking behaviour.

2 Government expenditures reduce wealth and hence consumption. Government multiplier is less than 1.

3 Taxes discourage work, optimal taxes should take the response of workers into account.

4 Without credit frictions the timing of taxes and stimuli are irrelevant.
7 Lessons to remember

5 Without capital accumulation technology cannot lead to sustained growth of standard of living.

6 Borrowing short and lending long makes the banking system prone to panics. Policy can prevent panics at no cost.

7 Money creation has no long run real effect. Unexpected inflation can have short term real effects.
Part III

Problem Sets
73-240 – Problem set 1

Due Friday Feb. 7th

From the Syllabus:

1. Homework must be turned in on the day it is due. Late homework will NOT be accepted unless you are sick and have a doctor’s note.

2. You may work in groups of up to 4. BUT: You MUST put names of other group members on your homework. You MUST write up your own set of answers.

3. TYPE your work. Long equations may be hand written. Buy a stapler!

4. Write your first and last name on the title of each graph. Graphs may be hand drawn.

5. Carefully explain your work.

Problem 1 (20 points)

Consider the following data:

<table>
<thead>
<tr>
<th>Quantities/Time</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Widgets</td>
<td>32</td>
<td>15</td>
</tr>
<tr>
<td>Blue Widgets</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>Prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Widgets</td>
<td>$1.75</td>
<td>$1.6</td>
</tr>
<tr>
<td>Blue Widgets</td>
<td>$2</td>
<td>$2.2</td>
</tr>
</tbody>
</table>

1. Compute the Laspeyres and Paasche indices for each year taking as base year 2013.

2. Compute Nominal GDP and its growth rate.

3. Compute Real GDP using both the Laspeyres and Paasche indices. Compute growth rates of real GDP using both indices.

4. Compute inflation in 2014 using both the Laspeyres and Paasche indices.
Problem 2 (15 points) A first glance at NIPA

1. Write the formula for GDP following the expenditure approach.

2. Refer to table 1.1.6 (Real Gross Domestic Product) of the NIPA tables. You can find them here http://www.bea.gov/iTable/index_nipa.cfm, click on “Begin Using the Data” then click on Section 1. Map each of they item in the formula of GDP in terms of expenditure approach to one of the line of table 1.1.6.

3. For each item in the formula of GDP compute the fraction of total GDP. You can pick the last quarter of 2012.

Problem 3 (15 points)

Problem 3 of Chapter 2 (page 65) In Williamson 5th edition.
(The wheat and bread economy.)

Problem 4 (30 points) Working with data: Forecasting

This question will introduce you to some data work, also refer to Lecture 3 for details.

Using data from http://research.stlouisfed.org/fred2/:

1. Use series (UNRATE): Civilian unemployment rate.
   (Hint: type UNRATE in the search box)

2. Compute the average (in percent) unemployment rate from 1950 to 2008.

3. Using a linear forecast (careful in deciding the data to use) predict when unemployment will hit the average unemployment rate from 1950 to 2008. Make sure to carefully explain all the steps you do.

Problem 5 (20 points) Working with data: Filtering

This question will introduce you to some data work, also refer to Lecture 3 for details.

Using data from http://research.stlouisfed.org/fred2/:
1. Use series (GDPCA): Real gross domestic product. Take data from 1980 to 2012 included. Compute the Hodrick-Prescot filter of the time series. This will be the trend of GDP.

2. Plot the trend over time.

3. Compute the deviation from trend of GDP. This will be the cyclical components.

4. Plot the cyclical component of GDP.
73-240 – Problem set 2
Due Monday Feb. 24th

From the Syllabus:
1. Homework must be turned in on the day it is due. Late homework will NOT be accepted unless you are sick and have a doctor’s note.

2. You may work in groups of up to 4. BUT: You MUST put names of other group members on your homework. You MUST write up your own set of answers.

3. TYPE your work. Long equations may be hand written. Buy a stapler!

4. Write your first and last name on the title of each graph. Graphs may be hand drawn.

5. Carefully explain your work.

Problem 1 (30 points): The U.S. firm

Consider the Cobb-Douglas production function:

\[ Y = zK^{\alpha}N^{1-\alpha} \]  

where \( \alpha \) is the share of capital in the production function

1. Write down the problem of the firm and determine the labor demand function.

2. Suppose wages \( (w) \) change by 1%, by how much does labor demand change?

3. Using the optimality condition of the firm, write down a formula to compute \( \alpha \) from the data.

4. Using data on Compensation of employees (BEA, NIPA Table 2.1 line 2) and GDP, compute \( \alpha \). Use yearly data from 1970 onwards and report the average value of alpha for this time period.

5. In a graph plot the time of \( \alpha \) changes by year. On the same graph plot the HP filtered version of the time series (see also Hw 1).
Problem 2 (30 points): The U.S. household

In this problem you will study the representative household. Suppose that the utility function is given by

\[ U(C, l) = \log(C) + \frac{1}{\delta} \log(l) \]

Where \( C \) is consumption, \( l \) is leisure, and \( 1/\delta \) is a parameter that determines how much the representative household values consumption versus leisure. Let \( h \) be the total time endowment, \( w \) the wage and \( \pi \) the dividend payments.

1. Write the problem of the household making sure to include the budget constraint (don’t forget taxes and dividends in the budget constraint)

2. Solve the household problem. This implies deriving two equations one providing a value of \( C \) and one for the value of \( l \). These two equation must only depend on \( h, \delta, w \) and \( \pi - T \).

3. Suppose \( \pi - T = 0 \). Derive the optimality condition for the household using first order conditions. Using the optimality condition write a formula for leisure. How does leisure change when wages change? Explain in terms of income and substitution effect.

4. Let’s calibrate the model to the US household. Keep \( \pi - T = 0 \). In US data we observe that households enjoy 2/3 of their time endowment in leisure. Given this fact derive a realistic value for the parameter \( \delta \).

5. Let’s simulate a recession. Suppose the wages decrease by 10% how do hours worked change? What happens to consumption? Explain in terms of income and substitution effect. For this question set \( w = 1 \) (initially) also set \( h = 1 \), \( \pi - T = 0.1 \) and use the value of \( \delta \) calculated in the previous step.

   - Hint: Be careful not to mix leisure with hours worked.
   - Also \( \pi - T \) is now different than zero!

Problem 3 (40 points): Health and the Macroeconomy

In this question you are asked to analyze the behavior of U.S. health spending at an aggregate level. The aggregate behavior of health spending in the U.S. is potentially worrying; in the next question you are asked to show that it might not be the case.

1. Use Information reported by the BEA in NIPA table 1.5.5. Compute the share of GDP due to health spending from 1970. Plot this time series. Explain which data series you will use.
2. Using the above data, compute a linear trend from 1970. Use this trend to forecast the share of health spending up to 2030. Plot the overall time series from 1970 to 2030.

3. **A model for health care.** Suppose a household has income equal to \( Y \). Suppose income can be spent on either consumption \( C \) or health goods \( H \). Suppose that consumption and health goods have prices equal to 1. Write the budget constraint for the household

   - Hint: note that there is not leisure decision, income is fixed and equal to \( Y \).

4. Suppose that health goods increase the enjoyment of consumption goods (think about being healthy and enjoying more consumption). Formally let the utility from \( H \) and \( C \) be given by

   \[
   U(C, H) = H^\gamma (b + \log(C))
   \]

   where \( b \) is a parameter that describes the “value of being alive” and \( \gamma \) is a given parameter. Write the problem of the household.

5. Using Excel solve the problem of the household. Set \( b = 15, \gamma = 0.2 \) and consider three distinct income levels \( Y = 10, 15, 35 \). Plot the share of income devoted to health care for this household. How does it change as income increases?

   - This is a hard step. In recitation the TA will help you with this step!

6. Look for a definition of luxury good. Using this definition and the results in the prior question, comment on the behavior of health care in the US. Provide a possible explanation for it’s behavior.
From the Syllabus:

1. Homework must be turned in on the day it is due. Late homework will NOT be accepted unless you are sick and have a doctor’s note.

2. You may work in groups of up to 4. BUT: You MUST put names of other group members on your homework. You MUST write up your own set of answers.

3. TYPE your work. Long equations may be hand written. Buy a stapler!

4. Write your first and last name on the title of each graph. Graphs may be hand drawn.

5. Carefully explain your work.

Problem 1 (25 points): Optimal Taxation

Refer to Lecture 8. Write a formula for the optimal top tax rate ($\tau$) that contains the elasticity of reported income with respect to tax rate ($e$).

1. Plot the optimal top tax rate over a range of $e$ going from 0.1 to 5. Assume that $a = 1.5$.

2. Find the top labor income tax rate in the US today (make sure to correctly cite your source). Call this value $\tau_{US}$. For what value of $e$ roughly we have $\tau = \tau_{US}$?

Problem 2 (25 points): Solow

Consider the Solow growth model. Derive an equation that determines the steady state level of capital per capita. Analyze the long-run effects on the steady state of the following changes to the environment:

1. Tax rates on savings are decreased, hence saving rates increase.

2. A fraction of the country capital stock gets destroyed. For this last case also explain in detail what happens in the short run (i.e. the transition to the new steady state)
Problem 3 (25 points): Malthus

Consider the Malthusian model of growth. Analyze the long-run effects on the steady state of the following changes to the environment:

1. Increase in the hygiene in medical practice increases the survival rates of newborns.
2. Following a war, the country losses land.

Note that you are required to support your argument with either graphs or equations!

Problem 4 (25 points): Solow and the US

In this question you will calculate the capital stock in the US. Your starting point will be the following equation (refer to lecture 10):

\[ K_{t+1} = K_t(1 - d) + I_t, \]  

(1)

where \( K_{t+1} \) is the capital stock in year \( t + 1 \), \( K_t \) in year \( t \), \( I_t \) investment in year \( t \). Set the depreciation rate \( d = 0.05 \). Use data from table 1.1.6 of the NIPA accounts. For GDP (line 1) and Investment (line 7). Use annual data from 1960 to 2013.

1. Calculate the level of capital in 1960 assuming that the capital output ratio for that year is equal to 2: \( K_{1960}/Y_{1960} = 2 \).
2. Using equation (1) and the value of \( K_{1960} \), calculate \( K_{t+1} \) for all years 1961 to 2013.
3. Plot the capital output ratio between 1960 to 2013.
From the Syllabus:

1. Homework must be turned in on the day it is due.

2. You may work in groups of up to 4. But: You must put names of other group members on your homework. You must write up your own set of answers.

3. Type your work. Long equations may be hand written. Buy a stapler!

4. Write your first and last name on the title of each graph. Graphs may be hand drawn.

5. Carefully explain your work.

**Problem 1 (30 points): Taxes and Household Behavior**

Consider the household in the two period model studied in Lecture 12. Study the impact on consumption today \( c \) and consumption tomorrow \( c' \) of the following changes in taxes (assume taxes are lump sum):

1. It is announced that this year every household in the US will receive a 10% reduction in this years taxes.

2. For this year you receive (and only you) a larger than expected tax refund.

**Problem 2 (40 points): The Dynamic Household**

Consider the problem of the household studied in Lecture 13 (with endogenous labor supply). Describe every symbol you use. Suppose the utility function in every period is \( U(c, l) \).

1. Write down the problem of the household. Make sure to write the objective function and all of the constraints. (Hint use the lifetime budget constraint)

2. Write down the four first order conditions for consumption today \( c \) consumption tomorrow \( c' \), labor today \( l' \) and labor tomorrow \( l'' \).
3. Show that two first order conditions can be combined so that $MRS_{c,c'} = 1 + r$.

4. Consider a graph plotting $c$ versus $c'$ show how a change in $r$ might affect the optimal choice of $c$ and $c'$.

Problem 4 (30 points): The Dynamic Firm

Consider the problem of the firm studied in Lecture 13.

1. Write the two period problem of the firm labeling every symbol.

2. Compute the first order condition for investment ($I$).

3. Show how changes in the interest rate ($r$) impact $I$.

4. Show how changes in tomorrow ($z'$) impact $I$. 
73-240 – Problem set 5

Due Wednesday April 30th

From the Syllabus:

1. Homework must be turned in on the day it is due.

2. You may work in groups of up to 4. But: You must put names of other group members on your homework. You must write up your own set of answers.

3. Type your work. Long equations may be hand written. Buy a stapler!

4. Write your first and last name on the title of each graph. Graphs may be hand drawn.

5. Carefully explain your work.

Problem 1 (20 points): Asymmetric Information


Problem 2 (30 points): The Effects of TFP Growth

For this question you will need to refer to Lecture 14. Suppose that both productivity today \( z \) and productivity tomorrow \( z' \) grow. Use the equilibrium diagrams (for current labor and goods market) to determine the effects this will have on current aggregate output, current employment, the current real wage, the real interest rate, consumption and investment. Explain your results.

Problem 3 (20 points): Limited Commitment

Problem 4 (20 points): Hyper-Inflations

In this question you are asked to work with data on money, prices indices and output. The data has been collected by Warren Weber (CMU Ph.D 69’) economist at the Minneapolis Federal Reserve Bank. I have attached the data in a separate file (hw-prices-money.xlsx) on Blackboard. In the tab “Prices” looking across countries, what is the biggest episode of inflation you observe over time? How large was inflation during this “hyper-inflation” period? In the tab “Money” locate in line 1 the series for M0 and M2. For the country you have identified experiencing a “hyper-inflation” episode, plot the behavior of the natural log of M0 and M2. Describe what you observe.

Problem 5 (10 points): The End

Write down one topic, result or fact you have learned from this class and would like to remember beyond the final examination.
73-240 – Problem set 6

Due Thursday May 1\textsuperscript{st} and Friday May 2\textsuperscript{nd}

Rules:

1. This homework is optional.

2. The grade of this homework will be averaged with your previous 5 problem sets if it will increase the average score. This way there is no risk in submitting the homework.

3. You may work in groups. Each group member must submit an answer independently.

Question 1

On Friday May 2\textsuperscript{nd} at 8:30AM (EST) the Bureau of Labor Statistics will release the Employment Situation for April 2014. In this homework you are asked to forecast some of the key metrics in this release. In particular answer the following:

1. Forecast 1: By what amount will Total Nonfarm Payroll Employment grow by.

2. Forecast 2: The Unemployment Rate.

Here are important guidelines and tips for the homework:

1. The numerical values of the forecast must be submitted here: \url{http://tinyurl.com/73240-hw6} by Thursday May 1\textsuperscript{st} at 11:59PM Pittsburgh time.

2. To homework will be graded not by the precision of the forecast but by the methodology used. A detailed description of the methodology used must be submitted in class on Friday May 2\textsuperscript{nd}.

3. Any official data including ADP data might be used to generate the forecast.

4. Any of the procedures studied in Lecture 3 or Lecture 856 will be acceptable (more advanced procedures are also welcomed).

5. A sample of the same release for March 2014 can be found here: \url{http://www.bls.gov/news.release/empsit.nr0.htm}
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