Open Economy Macroeconomics

Martín Uribe

This draft, January 2013

Chapter 1

Business Cycles Around the World

The Data

We examine annual data on per capita real output, private total consumption, investment, government consumption, exports, and imports.

The dataset includes 246 countries. We select 119 countries by requiring that they have at least 30 uninterrupted years of data for all variables.

The average sample is 1965-2010.

The source is the World Bank's WDI data base, available at databank.worldbank.org.

Trend Cycle Decomposition of a Time Series

Suppose y_t denotes the logarithm of real per capita GDP. The first step in empirical business-cycle analysis is to decompose y_t into its secular (or trend) component, y_t^s, and its cyclical component, y_t^c:

$$y_t = y_t^s + y_t^c.$$

Detrending Methods There are various methods for performing a trend-cycle decomposition, including

(1) Log-linear detrending.

(2) Log-quadratic detrending.

(3) Hodrick-Prescott (HP) filtering, and

(4) First differencing.

(5) Band-pass filtering.

Here, we will employ methods (2), (3) and (4).

Caution: The implied business cycle is not insensitive to the detrending method.

Log-Quadratic Detrending

Using OLS, run the regression

$$y_t = a + bt + ct^2 + \epsilon_t$$

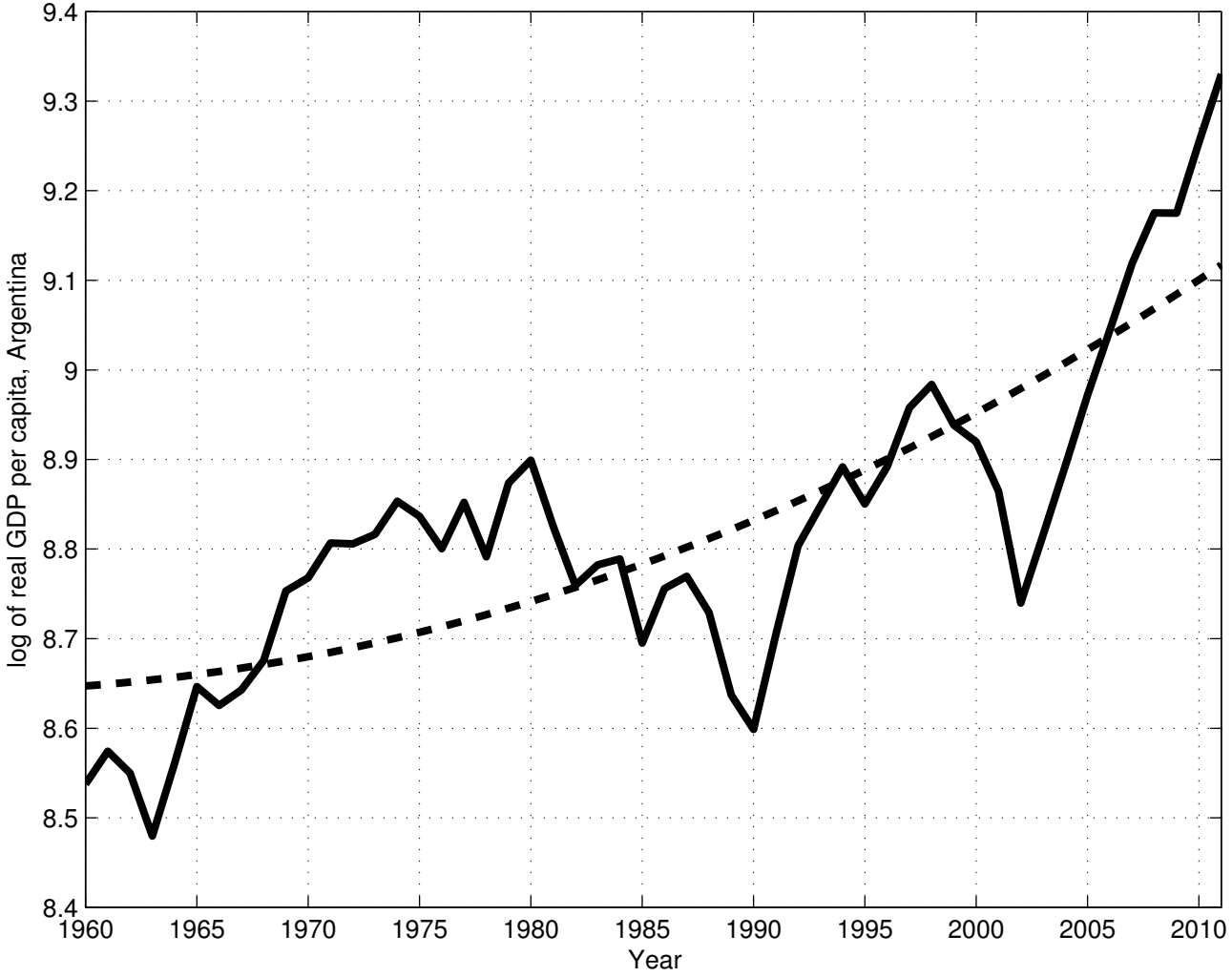
Then, the trend and cycle components of y_t are defined as

$$y_t^c = \epsilon_t$$

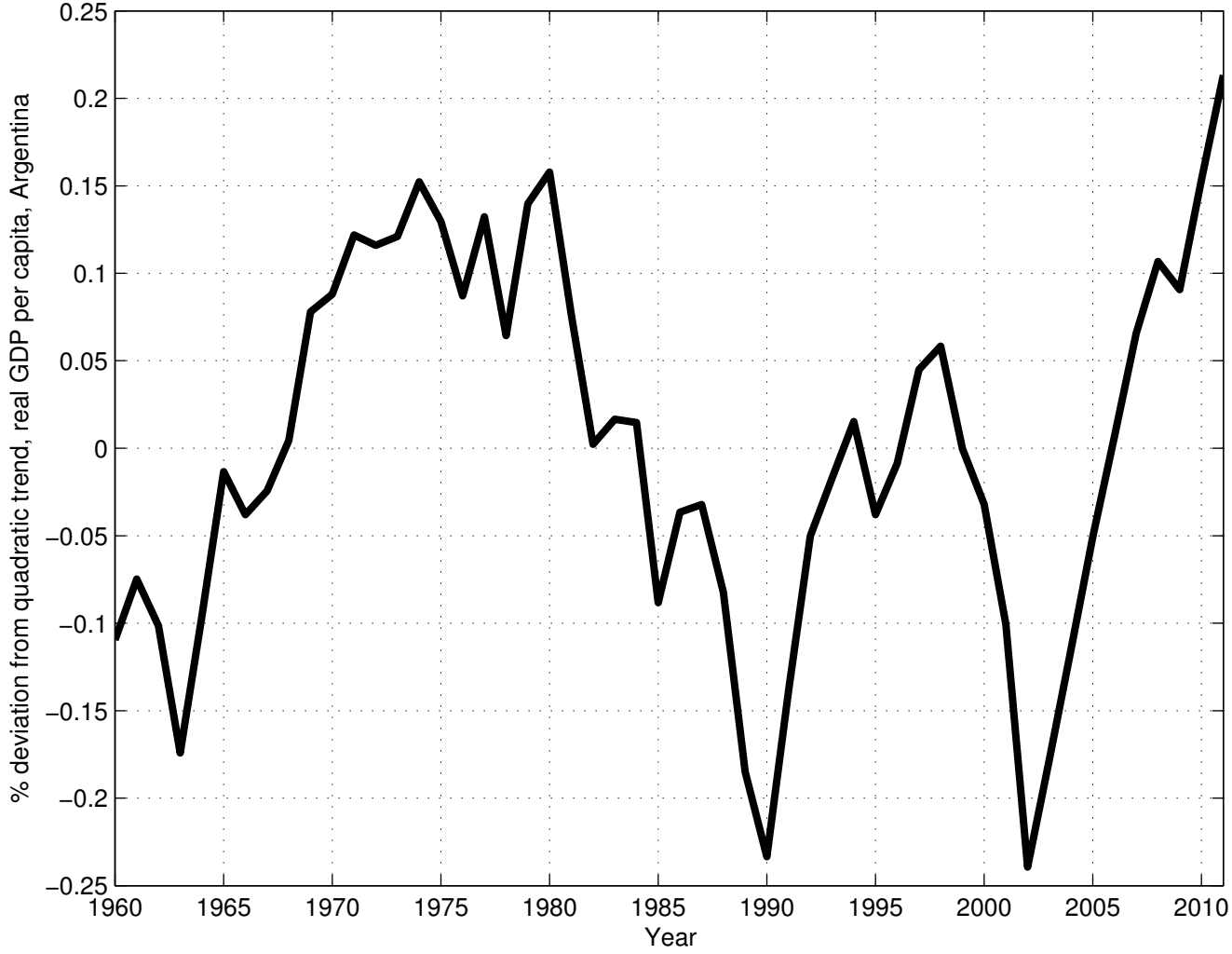
and

$$y_t^s = a + bt + ct^2.$$

Log-Quadratic Trend of Argentine real GDP per capita 1960-2011



Cycle of Argentine real GDP per capita: 1960-2011



Averaging and Grouping

All averages are population weighted.

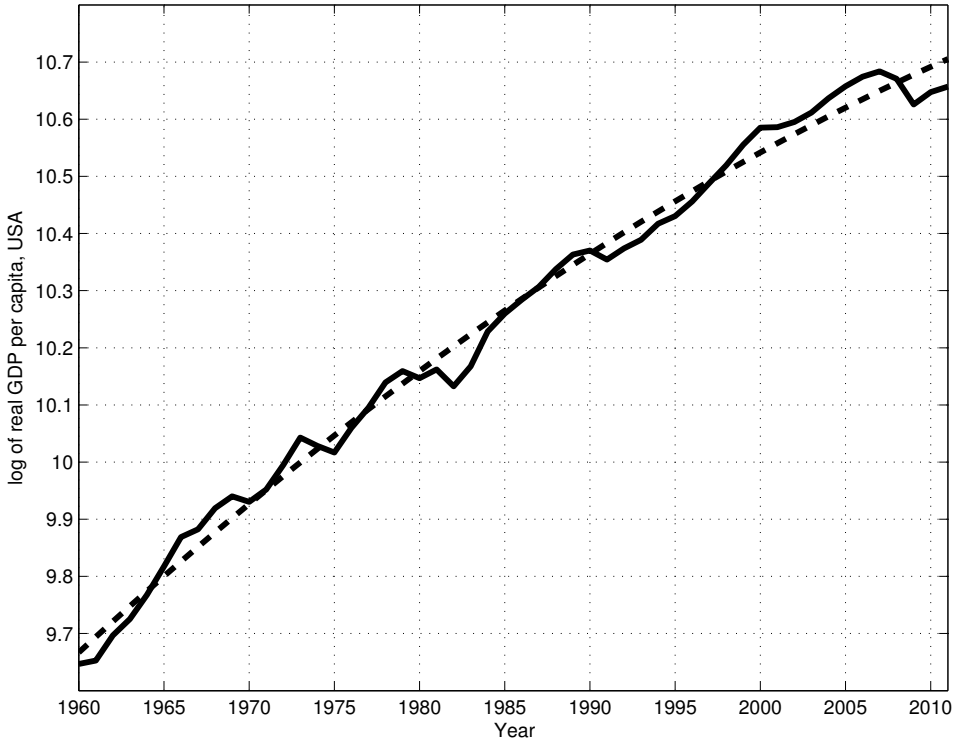
The sets of poor, emerging, and rich countries are defined as countries with average PPP converted real GDP per capital over the period 1990-2009 within the ranges 0-3000 dollars, 3000-25000, and 25000-∞, respectively.

High Global Volatility

Business-Cycle Statistic	World	USA
σ_y	6.2%	2.9%

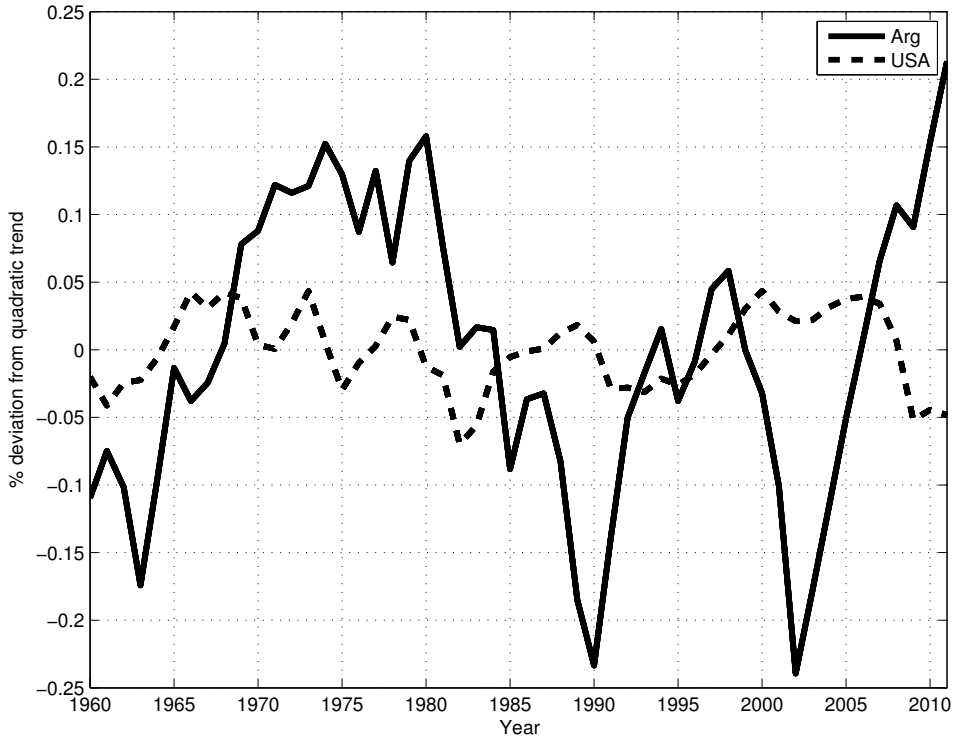
Fact 1: The cross-country average volatility of output is twice as large as its U.S. counterpart.

Trend of U.S. Real GDP per capita 1960-2011



Data Source: WDI Database and authors calculations.

Cyclical Components of Argentine and U.S, Real GDP per capita: 1960-2011



Data Source: WDI Database and authors calculations.

Global Excess Volatility of Consumption

Business-Cycle Statistic	World Average
$\frac{\sigma_c}{\sigma_y}$	1.05

Fact 2: On average across countries consumption is more volatile than output.

This fact must be taken with caution. Here, consumption includes expenditures in durables, nondurables, and services. Typically, expenditure on durables is excluded from the definition of consumption, as they represent investment in household capital, rather than direct consumption. Durable expenditure is highly volatile, and, even though it represents a relatively small fraction of total consumption, its inclusion in the definition of consumption may lead to a time series that is more volatile than output even if the sum of nondurables and services is less volatile than output.

High Volatility of Government Consumption

Business-Cycle Statistic	World Average
$\frac{\sigma_g}{\sigma_y}$	2.26

Fact 3: On average across countries government consumption is twice as volatile as output.

Global Ranking of Volatilities

Business-Cycle Statistic	World Average
$\frac{\sigma_m}{\sigma_y}$	3.23
$\frac{\sigma_i}{\sigma_y}$	3.14
$\frac{\sigma_x}{\sigma_y}$	3.07
$\frac{\sigma_g}{\sigma_y}$	2.26
$\frac{\sigma_c}{\sigma_y}$	1.05

Fact 4: The ranking of cross-country average standard deviations from top to bottom is imports, investment, exports, government spending, consumption, and output.

Procyclicality of the Components of Aggregate Demand

Business-Cycle Statistic	World Average
corr(c, y)	0.69
corr(i, y)	0.66
corr(x, y)	0.19
corr(m, y)	0.24

Fact 5: On average consumption, investment, exports, and imports are all positively correlated with output.

Countercyclicality of the Trade-Balance-to-Output Ratio

Business-Cycle Statistic	World Average
corr(tby, y)	-0.15

Fact 6: On average across countries the share of the trade balance in output is negatively correlated with output.

Acyclicality of the Share of Government Consumption in GDP

Business-Cycle Statistic	World Average
corr$(g/y, y)$	-0.02

Fact 7: On average across countries the share of government consumption in output is roughly uncorrelated with output.

Persistence

Business-Cycle Statistic	World Average
corr(y_t, y_{t-1})	0.71
corr(c_t, c_{t-1})	0.66
corr(g_t, g_{t-1})	0.76
corr(i_t, i_{t-1})	0.56
corr(x_t, x_{t-1})	0.68
corr(m_t, m_{t-1})	0.61

Fact 8: The components of aggregate supply (output and imports) and aggregate demand (consumption, government spending, investment, and exports) are all positively serially correlated.

Excess Volatility of Poor and Emerging Countries

Business-Cycle Statistic	Poor	Emerging	Rich
σ_y	6.1%	8.7%	3.3%

Fact 9: Business Cycles in rich countries are about half as volatile as business cycles in emerging or poor countries.

Less Consumption Smoothing in Poor and Emerging Countries

Business-Cycle Statistic	Poor	Emerging	Rich
σ_c/σ_y	1.12	0.98	0.87

Fact 10: The relative consumption volatility is higher in poor and emerging countries than in rich countries.

The Countercyclicality of the Trade Balance Increases With Income

Business-Cycle Statistic	Poor	Emerging	Rich
corr(tby, y)	-0.11	-0.21	-0.26

Fact 11: The trade-balance-to-output ratio is more negatively correlated with output the higher is the level of economic development.

The countercyclicality of Government Spending Increases With Income

Business-Cycle Statistic	Poor	Emerging	Rich
corr$(g/y, y)$	0.08	-0.08	-0.39

Fact 12: The share of government consumption is countercyclical in rich countries, but acyclical in emerging and poor countries.

The HP Filter Define the trend and cyclical components of y_t as the solution to the problem

$$\min_{\{y_t^c, y_t^s\}_{t=1}^T} \left\{ \sum_{t=1}^{T} (y_t^c)^2 + \lambda \sum_{t=2}^{T-1} \left[(y_{t+1}^s - y_t^s) - (y_t^s - y_{t-1}^s) \right]^2 \right\}$$

subject to

$$y_t = y_t^s + y_t^c$$

The first-order conditions of this problem are

$$y_1 = y_1^s + \lambda(y_1^s - y_2^s + y_s^3),$$

$$y_2 = y_2^s + \lambda(-2y_1^s + 5y_2^s - 4y_3^s + y_4^s),$$

$$y_t = y_t^s + \lambda(y_{t-2}^s - 4y_{t-1}^s + 6y_t^s - 4y_{t+1}^s + y_{t+2}^s); \quad t = 3, \ldots, T-2,$$

$$y_{T-1} = y_{T-1}^s + \lambda(y_{T-3}^s - 4y_{T-2}^s + 5y_{T-1}^s - 2y_T^s),$$

and

$$y_T = y_T^s + \lambda(y_{T-2}^s - 2y_{T-1}^s + y_T^s).$$

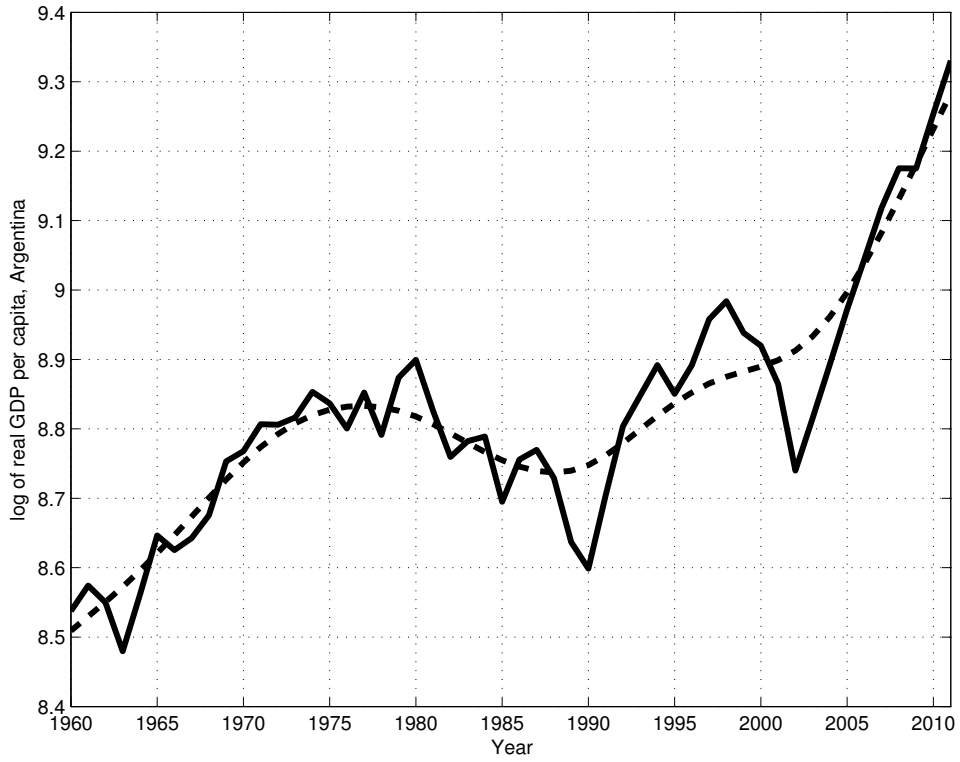
Letting $Y \equiv [y_1\, y_2\, \ldots y_T]$, $Y^s \equiv [y_1^s\, y_2^s\, \ldots y_T^s]$, and $Y^c \equiv [y_1^c\, y_2^c\, \ldots y_T^c]$, the above optimality conditions can be written in matrix form as

$$Y = (I + \lambda A)Y^s \Rightarrow Y^s = (I + \lambda A)^{-1}Y \text{ and } Y^c = Y - Y^s.$$

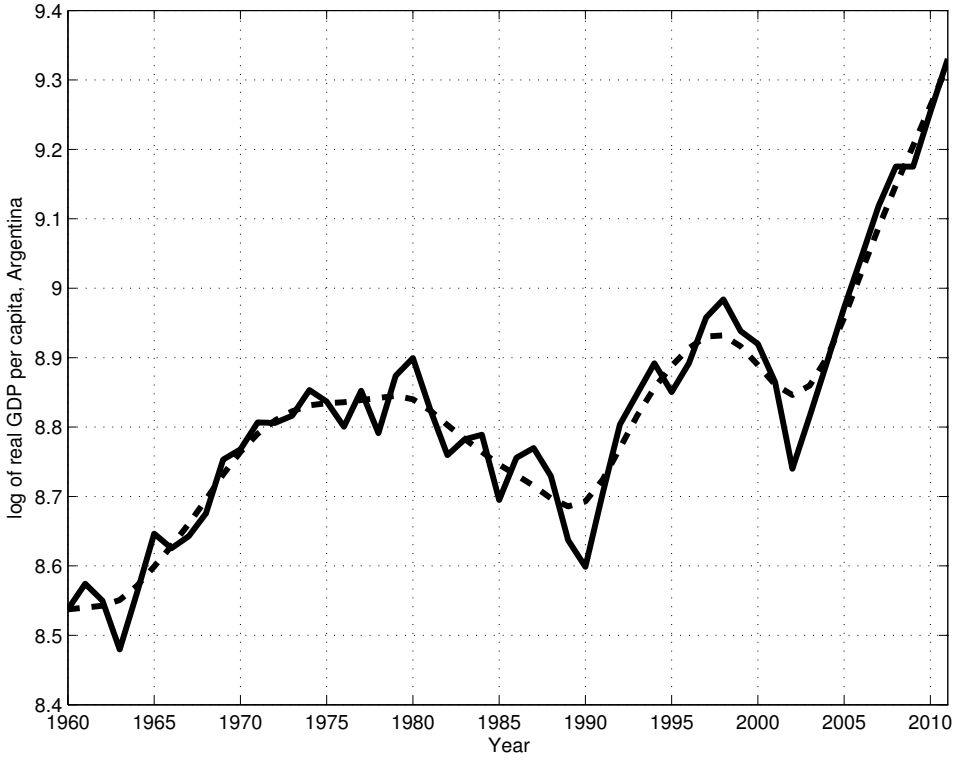
where I is the $T \times T$ identity matrix. and A is the following $T \times T$ matrix of constants

$$A = \begin{bmatrix} 1 & -2 & 1 & 0 & 0 & 0 & 0 & 0 & \ldots & 0 \\ -2 & 5 & -4 & 1 & 0 & 0 & 0 & 0 & \ldots & 0 \\ 1 & -4 & 6 & -4 & 1 & 0 & 0 & 0 & \ldots & 0 \\ 0 & 1 & -4 & 6 & -4 & 1 & 0 & 0 & \ldots & 0 \\ 0 & 0 & 1 & -4 & 6 & -4 & 1 & 0 & \ldots & 0 \\ \vdots & & & & & & & & & \vdots \\ 0 & \ldots & 0 & 1 & -4 & 6 & -4 & 1 & 0 & 0 \\ 0 & \ldots & 0 & 0 & 1 & -4 & 6 & -4 & 1 & 0 \\ 0 & \ldots & 0 & 0 & 0 & 1 & -4 & 6 & -4 & 1 \\ 0 & \ldots & 0 & 0 & 0 & 0 & 1 & -4 & 5 & -2 \\ 0 & \ldots & 0 & 0 & 0 & 0 & 0 & 1 & -2 & 1 \end{bmatrix}.$$

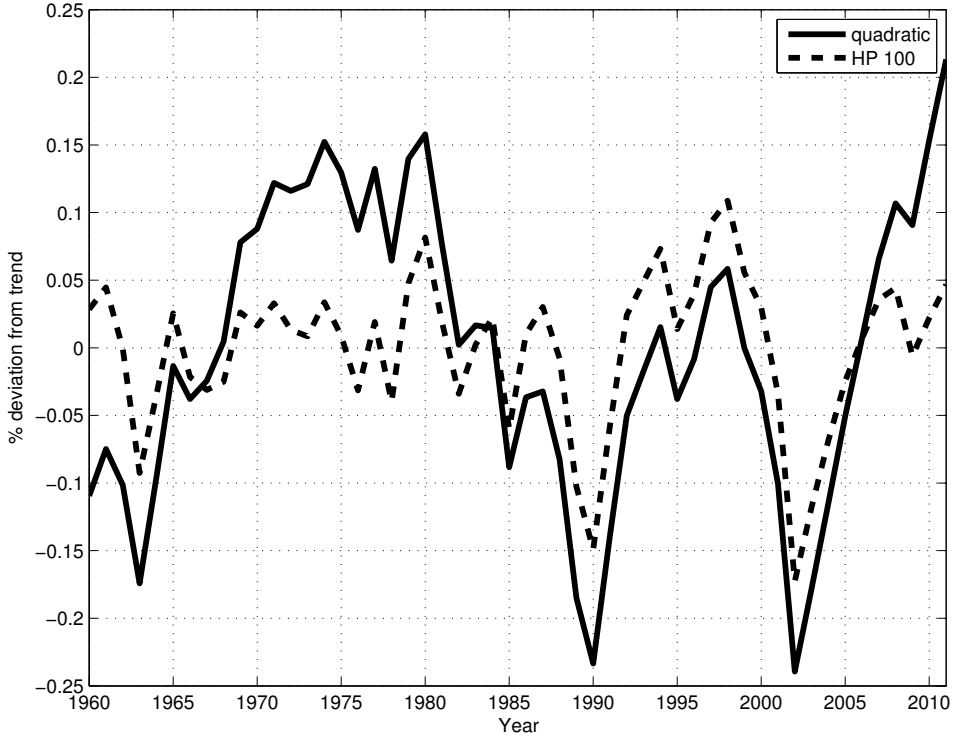
HP Filtered Trend of Argentine Output ($\lambda = 100$)



Trend of Argentine Output
HP Filter, $\lambda = 6.25$



Cyclical Component of Argetine GDP
HP Filter 100 Versus Quadratic Trend



Business Cycle Facts:

Log-Quadratic Detrending

versus

Hodrick-Prescott Filtering

High Global Volatility

Detrending Method	σ_y	
	World Average	USA
QT	6.2%	2.9%
HP	3.8%	2.0%

Fact 1: The cross-country average volatility of output is twice as large as its U.S. counterpart.

- Fact 1 continues to hold.

- Under HP filtering volatility falls by about 2/3.

Global Excess Volatility of Consumption

Detrending Method	World Average of $\frac{\sigma_c}{\sigma_y}$
QT	1.05
HP	1.08

Fact 2: On average across countries consumption is more volatile than output.

- Fact 2 continues to hold under HP filtering

High Volatility of Government Consumption

Detrending Method	World Average of $\frac{\sigma_g}{\sigma_y}$
QT	2.3
HP	2.3

Fact 3: On average across countries government consumption is twice as volatile as output.

- Fact 3 continues to hold under HP filtering

Global Ranking of Relative Volatilities

	QT	HP
$\frac{\sigma_m}{\sigma_y}$	3.2	3.7
$\frac{\sigma_i}{\sigma_y}$	3.1	3.8
$\frac{\sigma_x}{\sigma_y}$	3.1	3.5
$\frac{\sigma_g}{\sigma_y}$	2.3	2.3
$\frac{\sigma_c}{\sigma_y}$	1.1	1.1

Fact 4: Imports, investment, exports are about three times as volatile as output, government spending is twice as volatile, and private consumption is as volatile as output.

- Fact 4 continues to hold under HP filtering

Procyclicality of the Components of Aggregate Demand

	QT	HP
corr(c, y)	0.69	0.60
corr(i, y)	0.66	0.69
corr(x, y)	0.19	0.19
corr(m, y)	0.24	0.32

Fact 5: On average consumption, investment, exports, and imports are all positively correlated with output.

- Fact 5 continues to hold under HP filtering

Countercyclicality of the Trade-Balance-to-Output Ratio

	QT	HP
corr(tby, y)	-0.15	-0.18

Fact 6: On average across countries the share of the trade balance in output is negatively correlated with output.

- Fact 6 continues to hold under HP filtering

Excess Volatility of Poor and Emerging Countries

Detrending Method	σ_y		
	Poor	Emerging	Rich
QT	6.1%	8.7%	3.3%
HP	4.1%	4.0%	2.0%

Fact 9: Business Cycles in rich countries are about half as volatile as business cycles in emerging or poor countries.

- Fact 9 continues to hold under HP filtering

Consumption Smoothing Increases with Income

Detrending Method	σ_c/σ_y		
	Poor	Emerging	Rich
QT	1.12	0.98	0.87
HP	1.09	1.23	0.87

Fact 10: The relative consumption volatility is higher in poor and emerging countries than in rich countries.

- Fact 10 continues to hold under HP filtering.

The Countercyclicality of the Trade Balance Increases With Income

Detrending Method	corr(tby, y)		
	Poor	Emerging	Rich
QT	-0.11	-0.21	-0.26
HP	-0.08	-0.34	-0.37

Fact 11: The trade-balance-to-output ratio is more negatively correlated with output the higher is the level of economic development.

- Fact 11 continues to hold under HP filtering

The countercyclicality of Government Spending Increases With Income

Detrending Method	corr$(g/y, y)$		
	Poor	Emerging	Rich
QT	0.08	-0.08	-0.39
HP	0.02	-0.06	-0.56

Fact 12: The share of government consumption is countercyclical in rich countries, but acyclical in emerging and poor countries.

- Fact 12 continues to hold under HP filtering

Summary of Comparison

- QT and HP result in largely the same business cycle facts!

- The main difference is that HP filtering implies that the volatility of output and aggregate demand is 2/3 that implied by log-quadratic detrending.