Bad Inflation

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Low Growth, Low Inflation and Low Interest Rate

- 10 years ago, these phenomena were considered to be specific to Japan, but not anymore.
- What are the connections between them?
- In particular, what is the connection between growth and inflation?

Elusive Connection Between Inflation & Growth

$$\pi = \ln \beta + r - g_C \quad : \quad \text{Euler Eq}$$

- The long-run growth rate, g_C, is determined by the supply side.

- The central bank can achieve any long-run inflation π.
  - Any change in g_C is undone by adjusting the interest rate r.

$$\partial \pi = \underbrace{\partial r}_{=\partial g_C} - \partial g_C = 0.$$

- The dichotomy property breaks down when r is fixed for some reason, $\partial r = 0$.
  - An obvious example is Japan.

Tight Connection Between Inflation & Growth When $\partial r = 0$

$$\pi = \ln \beta + r - g_C \quad : \quad \text{Euler Eq.}$$

- Then any change in g_C can affect the long-run inflation.

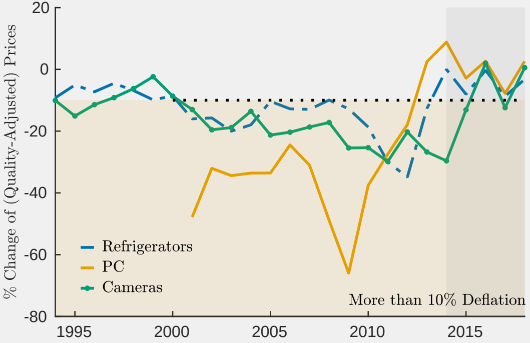
$$\partial \pi = \partial r - \partial g_C = -\partial g_C.$$

- Mechanically speaking, we have:
  - Slowdown of growth, $\partial g_C < 0$, implies inflation, $\partial \pi > 0$. (Bad inflation)
  - Consumption growth, $\partial g_C > 0$, implies deflation, $\partial \pi < 0$. (Good deflation)

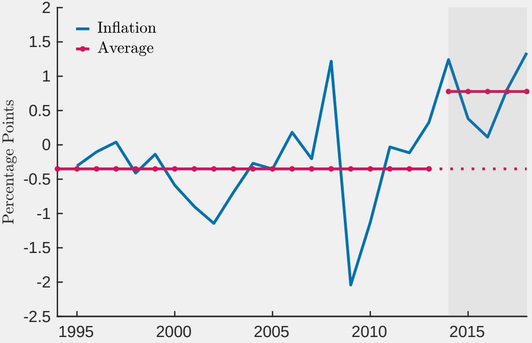
What we do:

- (1) build a multi-goods friction model and; (2) argue that this well-known, but under-appreciated, point plays a quantitative role for the Japanese economy in the last decade.

Motivating Evidence : Rise of Consumer Durable



Durable Consumption Goods



Inflation Rate

- What are the implications of these changes on growth (∂g_C) and inflation consequently?

Idea of Good Deflation and Bad Inflation is Shared Among Policymakers

- Ex BOJ Governor Hayami pointed out a possibility of good deflationary pressure.

  Though it is true that prices of a number of products have been declining, this is against the backdrop of various revolutionary changes including the so-called IT revolution, that is, the progress of technological innovation in information and telecommunications, as well as the revolution in distribution networks represented by the emergence of so-called "category killers." Such phenomena cannot necessarily be regarded as pernicious price declines. [Hayami (2000, Speech to the Research Institute of Japan)]

- Another side of his argument is that we might have bad inflation.

Overview

- Provide an accounting model which connects price changes, consumption growth, r, and π.
  - Extend a frictionless monetary model by incorporating many consumption and investment goods.
  - Derive sufficient statistics for change in inflation, and connect to observables.
- Introduce various macroeconomic facts about Japan after 1994.
  - The relative price of durables and ICT have stopped falling completely after 2013.
- Generalize the growth accounting exercises by using relative prices to estimate TFP.
  - The relative price stagnation of these goods translates into their TFP stagnation.
- Quantify the effect of depressed TFP growth on long-run inflation using the sufficient statistics.
  - We find that Inflation became positive after 2014 because of the depressed TFP growth.

Frictionless Monetary Model

Households' Problem

- The utility of the representative household is $U = \sum_{t=0}^{\infty} \beta^t L_t \ln \left(\prod_{i \in \mathcal{C}} D_{i,t}^{\gamma_i} \right)$. Jump

- Budget constraint is

$$\sum_{i \in \mathcal{C}} p_{i,t}^C C_{i,t} + \sum_{i \in \mathcal{I}} p_{i,t}^I I_{i,t} + \frac{B_t}{R_t} \leq \sum_{i \in \mathcal{I}} r_{i,t} K_{i,t} + W_t L_t + B_{t-1}$$

$$D_{i,t} = C_{i,t} + \left(1 - \delta_i^D\right) D_{i,t-1} : \text{Consumption}$$

$$K_{i,t+1} = I_{i,t} + \left(1 - \delta_i^K\right) K_{i,t} : \text{ Capital}$$

  - $D_{i,t}$ corresponds to $C_{i,t}$ (perishable consumption) if $\delta_i^D = 1$.
  - $\mathcal{C}$ is the set of consumption and $\mathcal{I}$ is the set of investment goods.
  - L_t is the number of (effective) workers population and inelastically supplied.

- The household maximizes its utility subject to the budget constraints.

Representative Firm in Sector $n \in \mathcal{C} \cup \mathcal{I}$

- The representative firm in sector n has ‣ Jump

$$Y_{n,t} = A_{n,t} \underbrace{\left(\prod_{i \in \mathcal{I}} K_{i,n,t}^{\alpha\theta_i} \right) L_{n,t}^{1-\alpha}}_{\text{Common Parameter across } n} = \begin{cases} C_{n,t} & n \in \mathcal{C} \\ I_{n,t} & n \in \mathcal{I} \end{cases}.$$

- The factor markets and the final good markets are competitive. So,

$$p_{n,t} = MC_{n,t} = \frac{1}{A_{n,t}} \underbrace{\left(\prod_{i \in \mathcal{I}} r_{i,t}^{\theta_i \alpha} \right) w_t^{1-\alpha}}_{\text{Common across } n} \rightarrow \left(\frac{p_{n,t}}{p_{m,t}} \right)^{-1} = \frac{A_{n,t}}{A_{m,t}}.$$

- Rapid rise of $A_{n,t}$ induces a big price decline of $p_{n,t}$.
  - The model says that the rapid decline of PC prices come from tech improvement.

Central Bank

- The central bank sets its nominal interest rate R_t and try to hit target inflation rate π^*.
  - Abstract from determinacy and discussion about the optimal inflation rate, π^*.

- The bond is zero net supply.

$$B_t = 0.$$

Market Clearing Conditions

- Good markets clearing conditions are

$$Y_{n,t} = A_{n,t} \left(\prod_{i \in \mathcal{I}} K_{i,n,t}^{\theta_i} \right)^{\alpha} L_{n,t}^{1-\alpha} = \begin{cases} C_{n,t} & n \in \mathcal{C} \\ I_{n,t} & n \in \mathcal{I} \end{cases}.$$

- The capital market clearing condition for each asset is

$$K_{i,t} = \sum_{n \in \mathcal{N}} K_{i,n,t} \quad \forall i \in \mathcal{I}.$$

- The labor market clearing condition is $L_t = \sum_{n \in \mathcal{C} \cup \mathcal{I}} L_{n,t}$.

- The bond market clearing condition is $B_t = 0$.

Equilibrium, BGP, and Macroeconomic Variables

- Competitive equilibrium is defined as usual.
  - We focus our analysis on BGP where all the variables grow at a constant rate.
  - Let g_{X_t} denote the logged growth rate and g_X the associated value along the BGP.

- Suppose the TFPs grow at constant rates: $g_{A_{n,t}} = g_{A_n}$ for all sectors $n \in \mathcal{C} \cup \mathcal{I}$.

- Define the real GDP growth, $g_{Y_t^*}$, inflation, and hourly wage as follows:

$$g_{GDP_t} \equiv \sum_{n \in \mathcal{C} \cup \mathcal{I}} s_{n,t-1} g_{Y_{n,t}}, \quad g_{C_t} \equiv \sum_{n \in \mathcal{C}} s_{c_n,t-1} g_{Y_{n,t}},$$

$$\pi_t \equiv \sum_{i \in \mathcal{C}} s_{c_i,t-1} g_{p_{i,t}}, \quad w_t \equiv \frac{W_t L_t}{H_t}.$$

  - $s_{n,t-1}$ is the GDP share of good n and $s_{c_n,t-1}$ is the nominal consumption share of good $i \in \mathcal{C}$.

Euler Equation Along BGP

- In our economy, the logged Euler equation along the BGP is

$$g_c = \sum_{i \in \mathcal{C}} s_{c_i} g_{c_i} = \ln \beta + \underbrace{r - \pi}_{\text{Real Interest Rate}} . \quad r = \ln R.$$

  - g_c corresponds to the growth rate of consumption per effective worker, $g_c = g_C - g_L$.
  - g_{c_i} is the growth rate of per-capita consumption good i.

- How does the model work?
  - When the TFP growth rates slow down, the output growth (and consumption) slows down.
  - To discourage high consumption growth, the rental rate of capital should go down.
  - Arbitrage implies that the real interest rate $r - \pi$ goes down.

The Long-Run Consumption Growth, g^*, Is Determined by the Supply Side

- Along the BGP, g_C is

$$g_c = \sum_{i \in \mathcal{C}} s_{c_i} g_{c_i} = \underbrace{\sum_{i \in \mathcal{C}} s_{c_i} g_{A_i}}_{\text{Direct Effect}} + \underbrace{\frac{1}{1-\alpha} \sum_{i \in \mathcal{I}} \alpha \theta_i g_{A_i}}_{\text{Capital Deepening Effect}} .$$

  - The s_{c_i} are the correct weights, not $\{\gamma_i\}_{i \in \mathcal{C}}$. ▸ HH
  - $\alpha\theta_i$ is output elasticity of capital stock i (power of capital stock of type i). ▸ Production

- Technological changes affect the long-run growth rate of consumption:

$$\partial g_c = \sum_{i \in \mathcal{C}} s_{c_i} \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{a \in \mathcal{I}} \theta_a \partial g_{A_a} + \underbrace{\sum_{n \in \mathcal{C} \cup \mathcal{I}} \sum_{i \in \mathcal{C}} g_{A_i} \frac{\partial s_i^C}{\partial g_{A_n}} \partial g_{A_n}}_{\text{Composition Effect} \approx 0} .$$

Sufficient Statistics for the Change of (Long-Run) Inflation When $\partial r = 0$

$$
\begin{aligned}
\text{[Inflation]} \quad : \quad \partial \pi &= \partial r + \partial \ln \beta - \partial g_c \\
&= \partial r + \underbrace{\partial \ln \beta}_{\text{Change of Preference}} + \underbrace{\sum_{i \in \mathcal{C}} s_{c_i} \left(-\partial g_{A_i} \right)}_{\text{Direct Effect}} + \underbrace{\frac{\alpha}{1-\alpha} \sum_{a \in \mathcal{I}} \theta_a \left(-\partial g_{A_a} \right)}_{\text{Capital Deepening Effect}}
\end{aligned}
$$

- The sufficient statistics connects the long-run growth rates of TFP with long-run inflation.
  - Note that (s_{c_i}, α) are observable, and we have an estimate for $(\theta_a)_{a \in \mathcal{I}}$.
- The last term $\partial \ln \beta$ captures all the non-technology effects on inflation.
  - E.g. aging (Fujita and Fujiwara (2021)) or rise of capital income risk (Braun and Nakajima (2012)) affect the discounting factor β endogenously.

Sufficient Statistics for Other Macro Variables When $\partial r = 0$

$$
\begin{aligned}
\text{[Inflation]} \quad &: \quad \partial \pi = \sum_{i \in \mathcal{C}} s_{c_i} \left(-\partial g_{A_i}\right) + \frac{\alpha}{1-\alpha} \sum_{a \in \mathcal{I}} \theta_a \left(-\partial g_{A_a}\right) + \partial \ln \beta \\
\text{[Nominal Wage]} \quad &: \quad \partial g_w = \partial \ln \beta + \underbrace{\left(\partial g_L - \partial g_H\right)}_{\text{Quality Improvement}} \\
\text{[Consumption Per } L\text{]} \quad &: \quad \partial g_c = \sum_{i \in \mathcal{C}} s_{c_i} \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{i \in \mathcal{I}} \theta_i \partial g_{A_i} \\
\text{[ALP]} \quad &: \quad \partial g_{GDP/L} = \sum_{i \in \mathcal{C} \cup \mathcal{I}} s_i \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{i \in \mathcal{I}} \theta_i \partial g_{A_i}.
\end{aligned}
$$

- When a negative TFP shock hits the economy, our model implies:
  - inflation rises (bad inflation);
  - the growth rate of the wage rate stays constant (so the real wage gets depressed); and
  - the growth of consumption and output declines.
- There is a disconnect between inflation and nominal wage.

Other Implication from Sufficient Statistics : Weak Consumption

$$\begin{aligned}
\text{[Inflation]} &: \quad \partial \pi = \sum_{i \in \mathcal{C}} s_{c_i} \left(-\partial g_{A_i}\right) + \frac{\alpha}{1-\alpha} \sum_{a \in \mathcal{I}} \theta_a \left(-\partial g_{A_a}\right) + \partial \ln \beta \\
\text{[Nominal Wage]} &: \quad \partial g_w = \partial \ln \beta + \left(\partial g_L - \partial g_H\right) \\
\text{[Consumption per } L\text{]} &: \quad \partial g_c = \sum_{i \in \mathcal{C}} s_{c_i} \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{i \in \mathcal{I}} \theta_i \partial g_{A_i} \\
\text{[ALP]} &: \quad \partial g_{GDP/L} = \sum_{i \in \mathcal{C} \cup \mathcal{I}} s_i \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{i \in \mathcal{I}} \theta_i \partial g_{A_i}.
\end{aligned}$$

- When a negative TFP shock of consumption good $i \in \mathcal{C}$ hits the economy, our model implies:

$$\partial g_{GDP} - \partial g_C = \underbrace{\left(s_i - s_{c_i}\right)}_{<0} \underbrace{\left(\partial g_{A_i}\right)}_{<0} > 0.$$

  - The growth rate of consumption will be lower than that of GDP. (weak consumption)
  - The effect on g_{GDP} is minor since the real GDP aggregates $\{g_{A_i}\}_{i \in I}$ by using nominal GDP shares.

Other Implication from Sufficient Statistics for GDP

$$
\begin{aligned}
\text{[Inflation]} \quad &: \quad \partial \pi = \sum_{i \in \mathcal{C}} s_{c_i} \left(-\partial g_{A_i}\right) + \frac{\alpha}{1-\alpha} \sum_{a \in \mathcal{I}} \theta_a \left(-\partial g_{A_a}\right) + \partial \ln \beta \\
\text{[Nominal Wage]} \quad &: \quad \partial g_w = \partial \ln \beta + \left(\partial g_L - \partial g_H\right) \\
\text{[Consumption per } L\text{]} \quad &: \quad \partial g_C = \sum_{i \in \mathcal{C}} s_{c_i} \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{i \in \mathcal{I}} \theta_i \partial g_{A_i} \\
\text{[ALP]} \quad &: \quad \partial g_{GDP/L} = \sum_{i \in \mathcal{C} \cup \mathcal{I}} s_i \partial g_{A_i} + \frac{\alpha}{1-\alpha} \sum_{i \in \mathcal{I}} \theta_i \partial g_{A_i}
\end{aligned}
$$

- When a negative TFP shock of investment good $i \in \mathcal{I}$ hits the economy, our model implies:

$$
\partial g_{GDP} - \partial g_C = \underbrace{s_i}_{>0} \times \underbrace{\left(\partial g_{A_i}\right)}_{<0} < 0.
$$

  - The growth rate of GDP will be lower than that of consumption.
  - Practically speaking, $\partial g_{GDP} \approx \partial g_C$ since s_i is very small for $i \in \mathcal{I}$.

Empirical Context

Main Datasets : JSNA and JIP

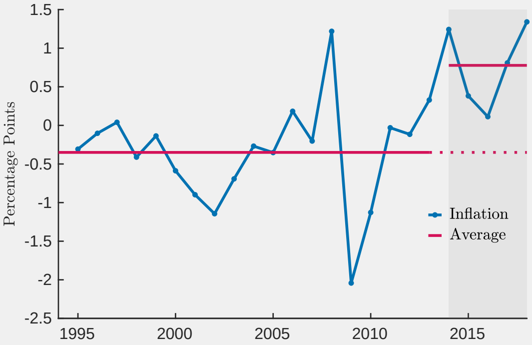
- National accounts of Japan (JSNA 2011)
  - Sample Period : 1994-2018.
  - Variables: consumption sequences, capital stock sequences, GDP, and the consumption deflator.
    - The consumption sequences are: (1) food; (2) nondurable; (3) durable; (4) services.
    - The capital stock sequences are: (1) total non-residential investment (structure); (2) transportation equipment; (3) information and communication technology (ICT); (4) other equipment; (5) weapons; (6) Cultivated assets; (7) R&D; (8) Other Intellectual products; (9) Computer software.
- We use the (normalized) consumption deflator, not the CPI. ▸ CPI
  - Innocuous adjustment : $\pi_t = \pi_t^{\text{Consumption Deflator}} - \pi_{1995}^{\text{Consumption Deflator}} + \pi_{1995}^{\text{CPI}}$.
- The labor service sequence in JIP2021 is used as labor input.
  - JIP2021 adjusts the quality of labor by the same method as the EU-KLEMS.
- We exclude housing from our analysis.

Aggregate Inflation Has (Weakly) Risen Since Around 2013

- The (consumption-tax-adjusted) inflation rate have risen since around 2013.

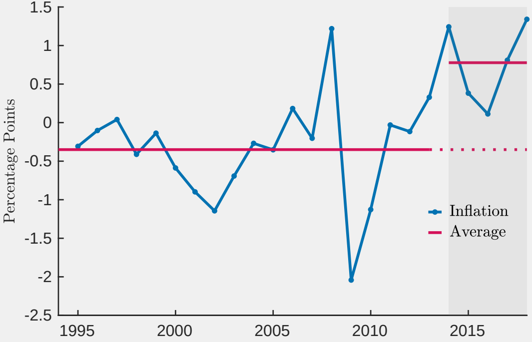
$$d\pi = \text{mean}\Big((\pi_t)_{t=2014}^{2018}\Big) - \text{mean}\Big((\pi_t)_{t=1994}^{2013}\Big)$$

$$= 1.13\%.$$



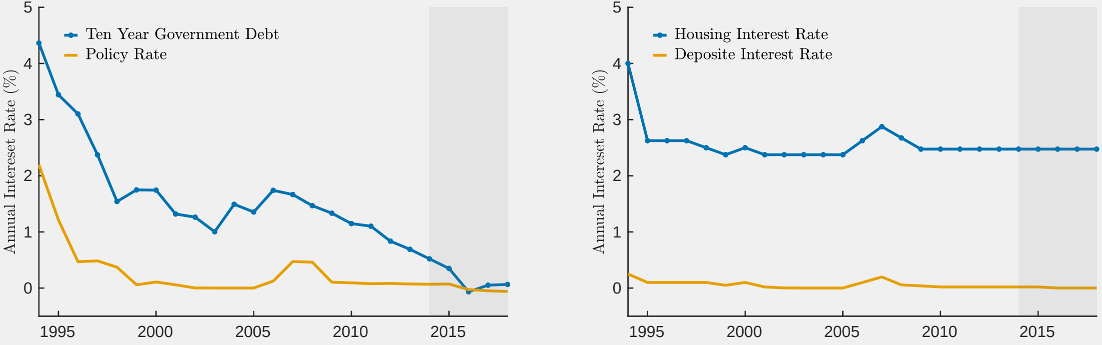
Aggressive Monetary Policy, “Kuroda Bazooka”, from 2013

- Conventional interpretation is that the recent rise of inflation is due to the aggressive monetary policy. (Hausman and Wieland (2015))
- The rise of inflation was considered to be a (partial) success for the BOJ.



- We re-examine this assessment by using the our frictionless model.

Nominal Interest Rate Has Been Low



- All the interest rates except the 10 year government debt have been constant.

$\rightarrow$ We conclude that $\mathrm{d}r = 0$.

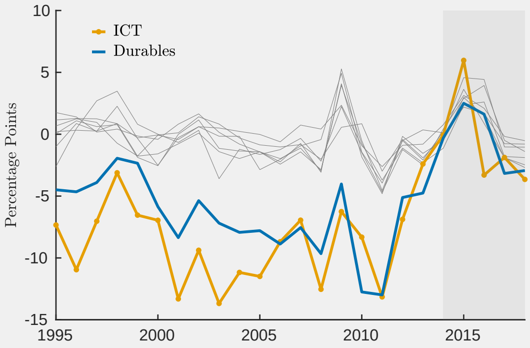
Relative Prices of ICT and Durables Have Risen

- Here we display

$$g_{p_{n,t}} - g_{p_{\text{Nondurable},t}}$$
$$\left(= g_{A_{\text{Nondurable},t}} - g_{A_{n,t}} \right).$$

- Except for consumer durables and ICT, the relative prices are stable.
  - Important to have this heterogeneity in the model.

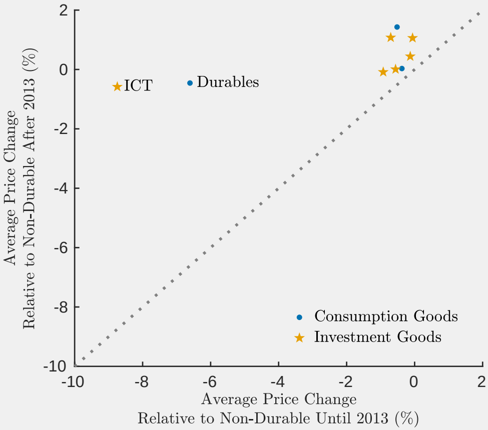
- These goods stopped declining relative to non-durable after 2013.



Growth Rate of Relative Prices

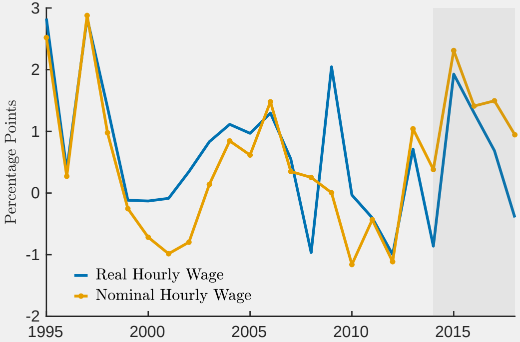
Relative Prices of ICT and Durables Have Risen

- We explore the implication of the changes of the relative prices on the aggregate inflation.

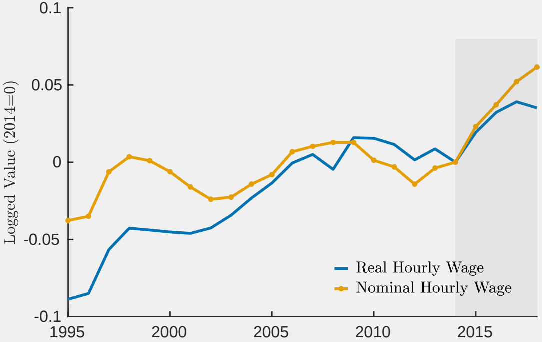


Growth Rate of Relative Prices

Wage Does Not Show a Clear Pattern



Growth Rate of Hourly Wage



Hourly Wage Level

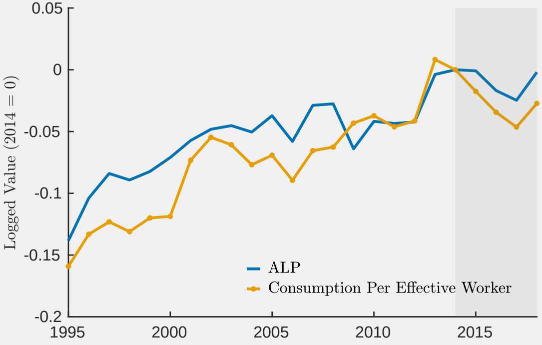
- The wage rates had depressed significantly after the recessions (1997,2007).
- Our theory has no prediction for nominal wage growth. Go Back

Weak Consumption Growth after 2013

- Aggregate consumption stopped growing completely after 2013.

$$\underbrace{dg_{GDP/L}}_{-0.63\%} = \underbrace{\text{mean}\left(\left(g_{GDP_t/L_t}\right)_{t=2014}^{2018}\right)}_{=0.67\%} - \underbrace{\text{mean}\left(\left(g_{GDP_t/L_t}\right)_{t=1994}^{2013}\right)}_{=0.04\%}$$

$$\underbrace{dg_{C/L}}_{-1.56\%} = \underbrace{\text{mean}\left(\left(g_{C_t/L_t}\right)_{t=2014}^{2018}\right)}_{=0.857\%} - \underbrace{\text{mean}\left(\left(g_{C_t/L_t}\right)_{t=1994}^{2013}\right)}_{=-0.71\%}.$$



GDP and Consumption

Mapping The Model To Data

Prerequisite for Estimation of Sectoral TFP

- JIP estimates the time-series of α (excluding housing) so we use the average.
- Use the real GDP excluding housing in JIP.
- In order to to estimate $(\theta_i)_{i \in \mathcal{I}}$, we use the method by Gourio and Rognlie (2020). ▸ Detail

Parameters $(\alpha, (\theta_i)_{i \in \mathcal{I}})$ and Average Shares in GDP s_n

	Capital Share α	Rental Share θ_i	GDP Share s_n	Consumption Share s_{cn}
	32%	$*$	$*$	$*$
Services	$*$	$*$	34.3%	50.2%
Non Durable	$*$	$*$	15.3%	22.4%
Food	$*$	$*$	11.8%	17.3%
Durable	$*$	$*$	**6.9%**	**10.1%**
Structure	$*$	34.2%	11.8%	$*$
Other Equipment	$*$	26.2%	8.0%	$*$
R&D	$*$	15.6%	4.7%	$*$
Software	$*$	8.6%	2.6%	$*$
ICT	$*$	**8.1%**	**2.4%**	$*$
Transportation Equipment	$*$	6.4%	1.9%	$*$
Weapons, Cultivated Assets, Other IPP	$*$	$< 0.6\%$	$< 0.2\%$	$*$

Estimation of Sectoral TFP and Shock

- The model implies:

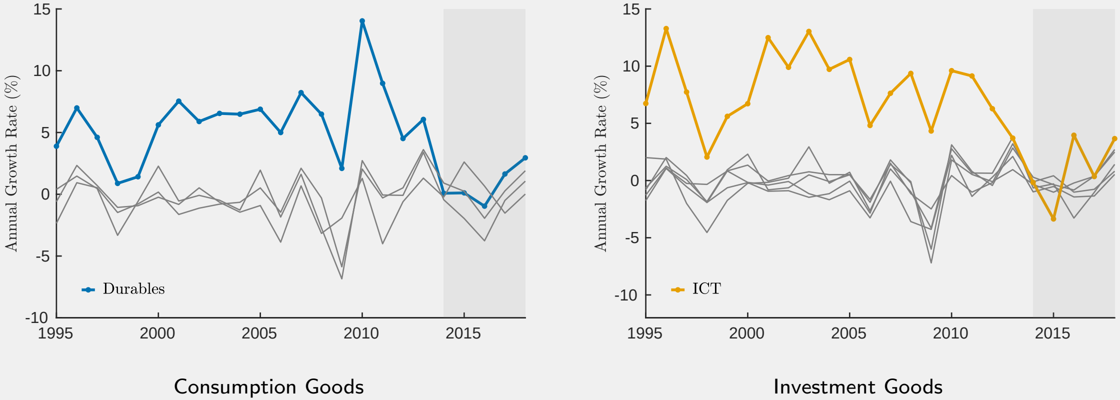
$$\underbrace{g_{GDP_t}}_{\text{JIP}} - \alpha \sum_{i \in \mathcal{I}} \theta_i \underbrace{g_{K_{i,t}}}_{\text{JSNA}} - (1-\alpha) \underbrace{g_{L_t}}_{\text{JIP}} = \sum_{n \in \mathcal{C} \cup \mathcal{I}} \underbrace{s_{n,t-1}}_{\text{JSNA}} g_{A_{n,t}}$$

$$\underbrace{g_{p_{n,t}} - g_{p_{\bar{n},t}}}_{\text{JSNA}} = g_{A_{\bar{n},t}} - g_{A_{n,t}} \quad \forall n \in n \in \mathcal{C} \cup \mathcal{I} \setminus \{\bar{n}\}.$$

- We use JSNA, JIP, and the estimated parameters.
- We have $\#(\mathcal{C} \cup \mathcal{I})$ equations, and $\#(\mathcal{C} \cup \mathcal{I})$ unknowns, $\{g_{A_{n,t}}\}_{n \in \mathcal{C} \cup \mathcal{I}}$, at each date t.
- Back out $\mathrm{d} \ln \beta$ by using a BGP property:

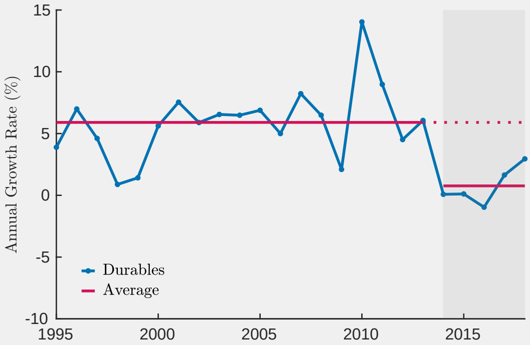
$$\underbrace{\mathrm{d}\pi}_{\text{Data}} = -\sum_{i \in \mathcal{C}} s_{c_i} \underbrace{\mathrm{d}g_{A_i}}_{\text{Estimated}} - \frac{\alpha}{1-\alpha} \sum_{a \in \mathcal{I}} \theta_a \underbrace{\mathrm{d}g_{A_a}}_{\text{Estimated}} + \mathrm{d} \ln \beta$$

Estimated TFP Growth Rates for Durables & ICT Stopped Improving

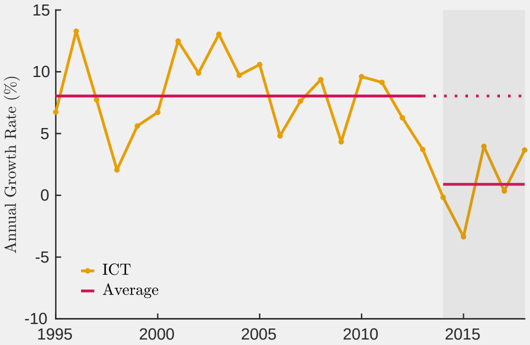


- Since around 2013, the sectoral TFP growth rates have equalized across the sectors.
- We only examine the shift of the productivity growth after 2013, not fluctuation.
  - Let dg_{A_i} denote the change of the average growth rate of good i before and after 2013.

Negative Technology Shocks of Consumer Durable and ICT



Durables



Communication and Computer Hardware (ICT)

- In our quantification exercises, we focus on tech stagnation of consumer durable and ICT sectors.
  - That is, we focus on the effect from $dg_{A_{\text{Durable}}}$ and $dg_{A_{\text{ICT}}}$.

Model Fit Before Quantification

- Compute the model-implied changes:

$$\text{[Inflation]} \quad : \quad \mathrm{d}\pi = \sum_{i\in\mathcal{C}} s_{c_i}\left(-\mathrm{d}g_{A_i}\right) + \frac{\alpha}{1-\alpha}\sum_{a\in\mathcal{I}}\theta_a\left(-\mathrm{d}g_{A_a}\right) + \underbrace{\mathrm{d}\ln\beta}_{\text{Chosen to satisfy this eq.}}$$

$$\text{[Nominal Wage]} \quad : \quad \mathrm{d}g_w = \mathrm{d}\ln\beta + \underbrace{\left(\mathrm{d}g_L - \mathrm{d}g_H\right)}_{\text{JIP}}$$

$$\text{[Consumption per } L\text{]} \quad : \quad \mathrm{d}g_c = \sum_{i\in\mathcal{C}} s_{c_i}\mathrm{d}g_{A_i} + \frac{\alpha}{1-\alpha}\sum_{i\in\mathcal{I}}\theta_i\mathrm{d}g_{A_i}$$

$$\text{[ALP]} \quad : \quad \mathrm{d}g_{GDP/L} = \sum_{i\in\mathcal{C}\cup\mathcal{I}} s_i\mathrm{d}g_{A_i} + \frac{\alpha}{1-\alpha}\sum_{i\in\mathcal{I}}\theta_i\mathrm{d}g_{A_i}$$

  - For s_{c_i} (consumption share) and s_i (GDP share), we use their average.

- Compare these changes with their data-counterpart.

Model Fit

Variable	Description	Data	Model (BGP)	Change (Fraction)
			Internal	
$d\pi$	Inflation	1.13%	1.13%	(100%)
$dg_{GDP/L}$	GDP Per L_t	-0.63%	-0.37%	(60%)
			External	
$dg_{C/L}$	Consumption Per L_t	-1.56%	-0.38%	(25%)
dg_w	Nominal Wage	NA(-1.00%)	0.22%	(22%)
$dg_w - d\pi$	Real Wage	NA(-0.13%)	-0.90%	(68%)

- The real variables are well approximated by BGP.

Quantitative Implication for Long-Run Inflation

- Use the sufficient statistics to quantify the effect from the tech slowdown of durables and ICT.
  - Sufficient Statistics

$$
\begin{aligned}
\text{[Inflation]} &: \quad d\pi^{\text{Tech}} = -s_{c_{\text{Durable}}} dg_{A_{\text{Durable}}} - \frac{\alpha}{1-\alpha}\theta_{\text{ICT}} dg_{A_{\text{ICT}}} \\
\text{[Nominal Wage]} &: \quad dg_w^{\text{Tech}} = 0 \\
\text{[Consumption per } L\text{]} &: \quad dg_{C/L}^{\text{Tech}} = s_{c_{\text{Durable}}} dg_{A_{\text{Durable}}} + \frac{\alpha}{1-\alpha}\theta_{\text{ICT}} dg_{A_{\text{ICT}}} \\
\text{[ALP]} &: \quad dg_{ALP}^{\text{Tech}} = s_{\text{Durable}} dg_{A_{\text{Durable}}} + \frac{\alpha}{1-\alpha}\theta_{\text{ICT}} dg_{A_{\text{ICT}}}
\end{aligned}
$$

  - $d\pi^{\text{Tech}}$ represents the effect from technology stagnation of durables and ICT on inflation.

- Since $dg_{A_{\text{Durable}}}, dg_{A_{\text{ICT}}} < 0$, our model predicts inflation rises, bad inflation.

Quantitative Effect of Technology Stagnation

	Quantification			Decomposition			
				Durable		ICT	
Variable	Data	Model	(Fraction)	(Weight)	$(-dg_{A_i})$	Weight	$-dg_{A_i}$
$d\pi$	1.13%	**0.76%**	(67%)	0.51%		0.23%	
				(0.10)	(5.1%)	(0.03)	(7.2%)
$dg_{C/L}$	-1.56%	-0.76%	(49%)	-0.54%		-0.23%	
				(0.10)	(5.1%)	(0.03)	(7.2%)
$dg_{GDP/L}$	-0.63%	-0.59%	(94%)	-0.54%		-0.23%	
				(0.07)	(5.1%)	(0.03)	(7.2%)

- The mere technology stagnation of durable ICT significantly lowers (long-run) inflation.

Quantitative Effect of Technology Stagnation

Quantification

Variable	Data	Model	(Fraction)
$dg_{GDP/L} - dg_{C/L}$	0.92%	0.17%	(18%)
$dg_w - d\pi$	NA	-0.77%	$*$

- The technology stagnation under-predicts weak investment, but the shocks are not sizable enough.
- The technology stagnation predicts sharp real wage stagnation.

Counter-Factual Exercises

- Suppose that the technology stagnation after 2013 had not occurred.

$$\pi_{\text{After 2013}} : 0.77\% \rightarrow 0.01\%.$$

  - Technology stagnation induced positive inflation after 2013.

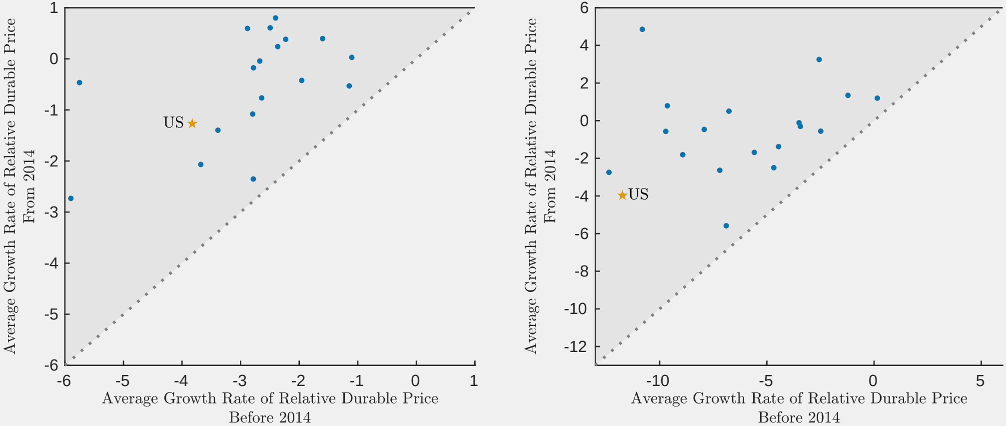
- Suppose that the technology improvement before 2013 had not occurred in the first place.

$$\pi_{\text{Before 2013}} : -0.35\% \rightarrow 0.41\%.$$

  - The mild deflation during 2000s would not have happened.

Robustness Exercises

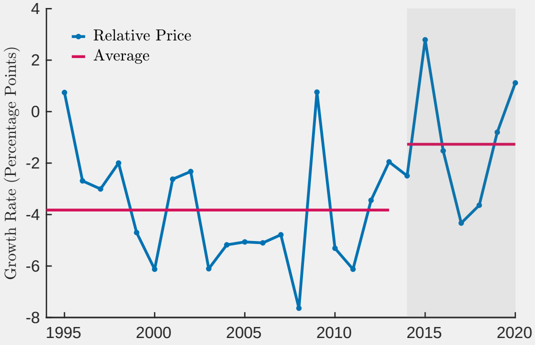
Cross-Country Evidence



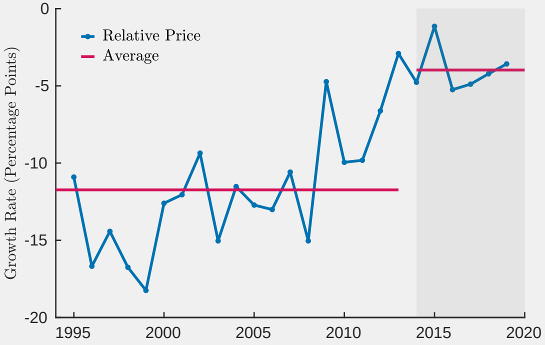
Sample: Austria,Belgium,Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom, United States.

- See Takahashi and Takayama (2021) which explores implication for growth.

Cross-Country Evidence : Timing Varies Across Countries



Relative Price of Durable of the US



Relative Price of ICT of the US

- We use $t = 2014$ as our benchmark for Japan.
  - This benchmark year might not be completely suitable for other countries, e.g. the US.

Robustness : JIP's Estimate of ICT Technology

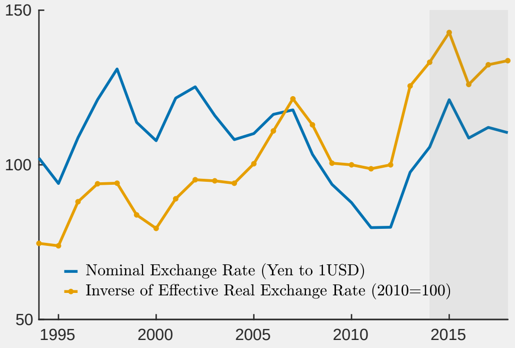
- Price information might be contaminated. E.g. exchange rate, import...
- JIP (Japanese KLEMS) directly estimates sectoral TFP growth rates with a general CRS production F.

$$Y_{n,t} = A_{n,t} F\left(K_{n,t}, L_{n,t}, M_{n,t}\right).$$

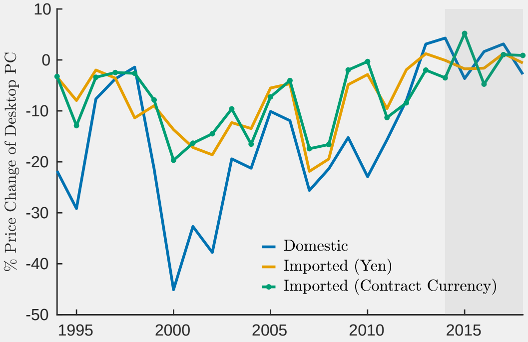
- The ICT TFPs estimated by the KLEMS show more significant technology slowdown than ours.

	KLEMS		Our Estimate
Period	CT	IT	ICT
1994-2013	5.3%	8.3%	8.1%
2014-2018	–9.4%	0.0%	1.2%
Change	−14.7%	−8.3%	−6.9%

Robustness : Effect From Nominal Exchange Rate



Exchange Rates



PC Prices in PPI

Conclusion : Implication for Japan

- Policy evaluation of “Kuroda bazooka (2013)” needs to be done carefully.
  - Tech stagnation of durables and ICT happened around the same time, which is something BOJ cannot control.
- Simple judgment of monetary policy is not desired.
  - The cause behind 2% inflation is important.

Additional Slides

Estimation of Rental Rates $\{\theta_i\}_{i \in \mathcal{I}}$ by Gourio and Rognlie (2020)

Go Back

- Connect the rental rates with easily measured objects by using the model.
- Assume there are no growth (for simplicity). Arbitrage implies the user cost formula:

$$r_i = \left(r + \delta_i^K\right) p_i \quad r = \beta^{-1} - 1.$$

- Nominal depreciation is related with the new investment:

$$r_i K_i = \left(r + \delta^K\right) p_i K_i \Longrightarrow r_i K_i = r p_i K_i + \underbrace{\delta_i^K p_i K_i}_{\text{Investment}} = r p_i K_i + p_i I_i.$$

- The rental rate for a is expressed in terms of observables.

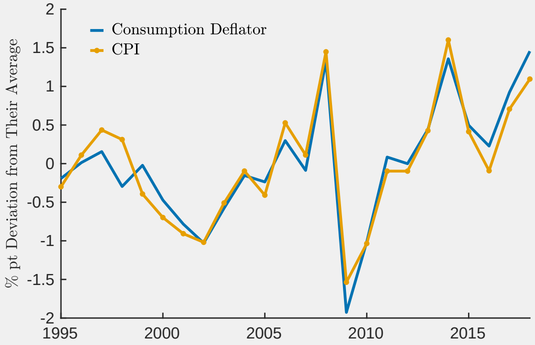
$$\theta_i = \frac{r_i K_i}{\sum_{a \in \mathcal{I}} r_a K_a} = \underbrace{s_I}_{\text{Total Investment Share}} / \alpha \underbrace{\frac{p_i I_i}{\sum_{a \in \mathcal{I}} p_a I_a}}_{\text{Investment Share of } i} + (1 - s_I/\alpha) \underbrace{\frac{p_i K_i}{\sum_{a \in \mathcal{I}} p_a K_a}}_{\text{Capital Share of } i}.$$

CPI VS Consumption Deflator in National Accounts

Go Back

- There are transitory differences between consumption deflator and CPI, but not permanent.
- We have:

$$d\pi^{\text{CPI}} = .94\%$$
$$d\pi^{\text{JSNA}} = 1.1\%.$$



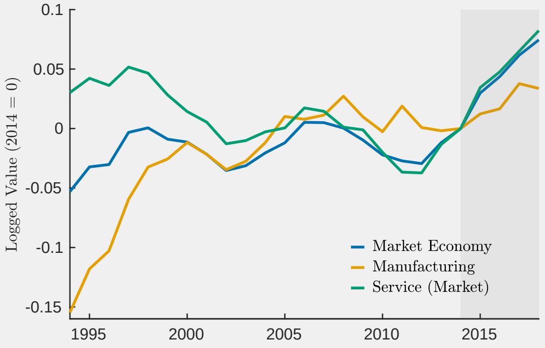
Consumption Tax Adjustment

Go Back

	CPI Excluding Imputed Rent Fixed Weight			CPI Excluding Imputed Rent Chain-Linked		Consumption Deflator Excluding Imputed Rent Chain-Linked	
Year	YoY	VAT-Adjusted	Diff	YoY	VAT-Adjusted	YoY	VAT-Adjusted
⋮	⋮	⋮	⋮				
2013	0.5%	0.5%	0.0%	0.4%	0.4%-0.0%	-0.1%	-0.1%-0.0%
2014	**3.3%**	**1.5%**	**1.8%**	3.4%	3.4%-**1.8%**	2.6%	2.6%-**1.8%**
2015	1.0%	0.3%	0.7%	1.1%	1.1%-0.7%	0.7%	0.7%-0.7%
2016	-0.1%	-0.1%	0.0%	-0.1%	-0.1%-0.0%	-0.3%	-0.3%-0.0%
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

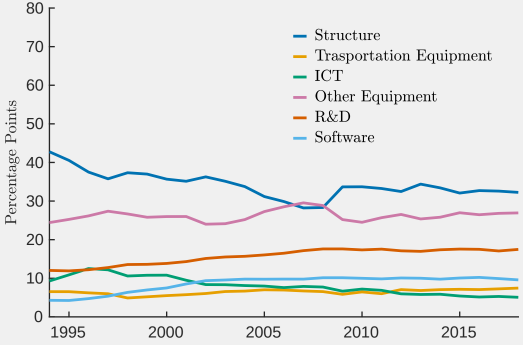
- Consumption tax was raised in 1997, 2014 (5% $\rightarrow$ 8%), and 2019.

Sectoral Nominal Wage

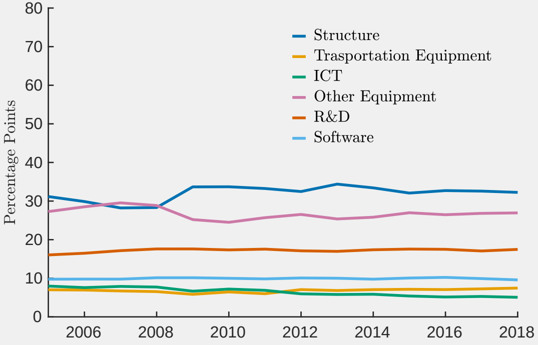


- There are substantial heterogeneity between the sectors. Go Back

Time-Series Estimates of $(\alpha, (\theta_i)_{i\in\mathcal{I}})$



From 1994 to 2018



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