Unmeasured investment and the puzzling lost decades of the Japanese economy

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Highlights

- First time to apply McGrattan and Prescott (2010)'s RBC theory extended with intangible investment to an economy other than the US

- The simulation result from this extended theory better explains the lost decades of the Japanese economy than that from the basic RBC model.

A recap of RBC

- Business cycles are mainly driven by productivity shocks.

- Implications: when productivity shocks and government purchases shocks are incorporated, the simulation results should be close to the reality.

- Existing literature also argues that the lost decades of the Japanese economy are mainly driven by productivity shocks (Hayashi and Prescott, 2002; Fukao et al., 2006; Griffin and Odaki, 2009).

A recap of RBC

However, things seem to have changed since 1990s.

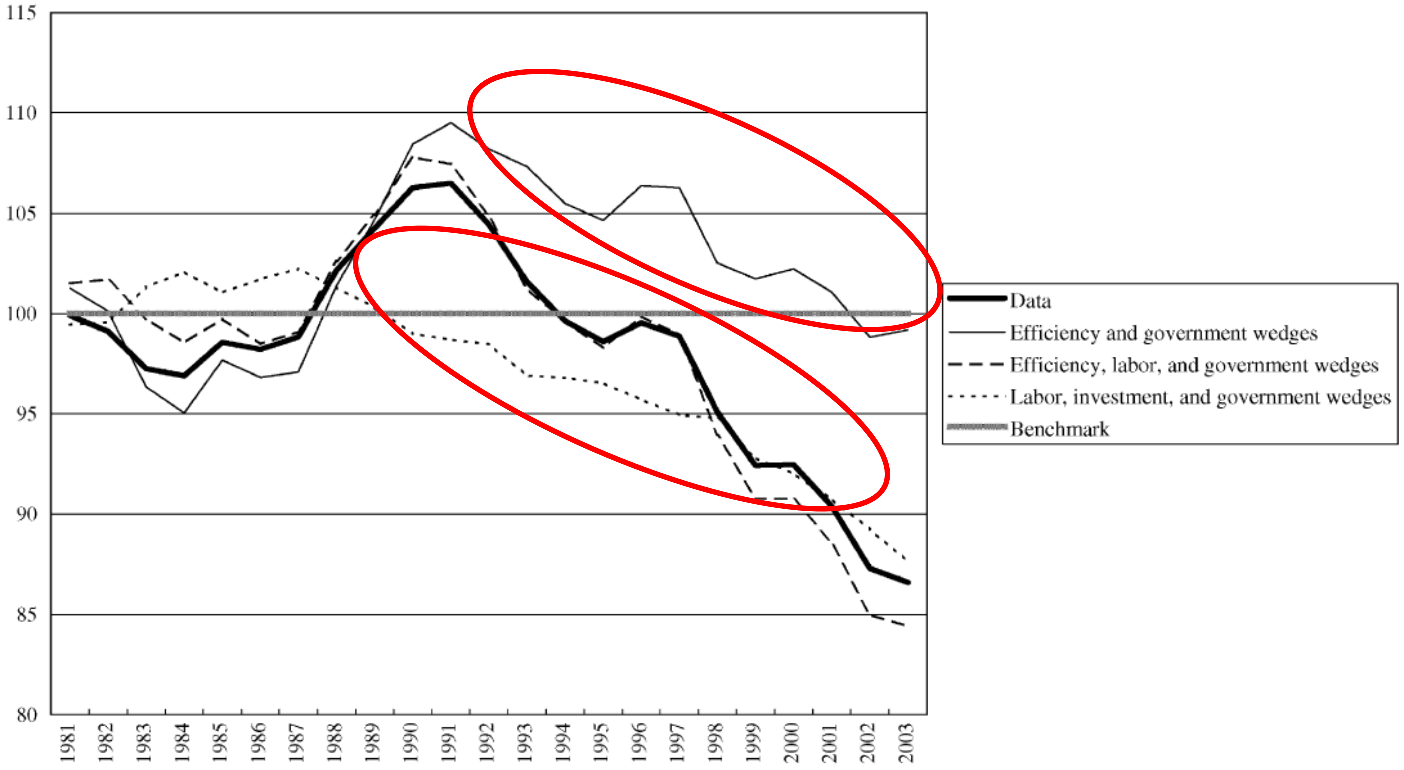


Fig. 3. Combined effect of two and three wedges on output.

Source: Figure 3 in Kobayashi and Inaba (2006).

A recap of RBC

- Hayashi and Prescott (2002) explains the pre-1995 change by arguing that there is a policy change in working hours limit.

- However, the deviation keeps increasing after 1995. Why?

A recap of RBC

A similar phenomenon happened in the US. See McGrattan and Prescott (2010) ; McGrattan and Prescott (2014).

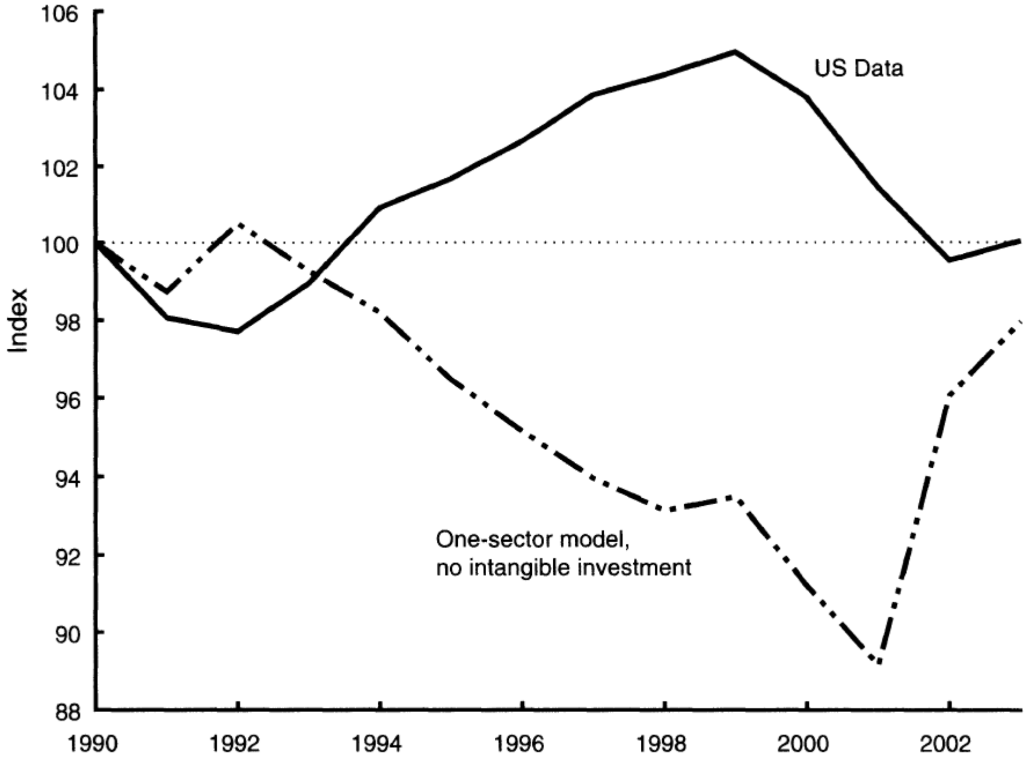


Figure 1. US and Basic Model Per Capita Hours Worked
(*Annual*, 1990 = 100, 1990–2003)

Source: McGrattan and Prescott (2010)

A recap of RBC

During the downturn of 2008–2009, output and hours fell significantly, but labor productivity rose (McGrattan and Prescott,2014).

Not consistent with the predictions of current macrotheories that assume business cycles are driven by fluctuations in total factor productivities of firms!

McGrattan and Prescott (2010) and McGrattan and Prescott (2014) argue that the unmeasured intangible investment may be the reasons for this phenomenon and propose an extended theory with intangible investment and non-neutral technology.

A recap of RBC

- Economic income vs measured income

- If the economic income does not move together with the measured income, then the measured productivity shocks may be biased.
- In the US case, during the GFC, the unmeasured intangible investment declined significantly, which means the measured productivity is higher than the actual productivity (McGrattan and Prescott,2014).
- For the 1990s and early 2000s period, the unmeasured intangible investment increased significantly, much higher than that of measured income, which means the measured productivity is lower than the actual productivity (McGrattan and Prescott,2010).

A recap of RBC

Some observations

- From 1985 to 1992, real intangible investment in the Japanese economy grew by 48% while it only grew respectively by 14% and 9.6% from 1992 to 1999 and from 1999 to 2006 in real terms

- During the Asian Financial Crisis, Japanese output and working hours fell significantly while labour productivity rose or fell much less than the output and working hours.

A recap of RBC

The decline in productivity may be underestimated in the case of Japan.

Unmeasured income might fall much more than the measured income.

Contribution

- The first to apply this new theory proposed by McGrattan and Prescott (2010) to a country other than the US and finds that this new theory works well in Japan, even using a simpler version.

- Better explains the depression in labour hours of Japan by avoiding introducing a large, unjustified labour wedge or other exogenous inputs.

- Add tangible investment adjustment costs as a robustness check and find this new theory remains robust for the case of Japan.

Basic model

In a standard one-sector neoclassical growth model, given the initial capital stock k_0, a representative household chooses consumption *c*, investment *x* and working hours *h* to maximize

$$\mathrm{E}_0[\sum_{t=0}^{\infty} \beta^t U(c_t, h_t) N_t]$$

subject to

$$c_t + x_t = \boxed{(1 - t_{wt})} w_t h_t + r_t k_t + T_t$$
$$k_{t+1} = [(1 - \delta)k_t + x_t]/(1 + n)$$

Effective labour income tax rate
(Labour market frictions)

Basic model

The aggregate production function is labour augmented and in the form of Cobbs-Douglas, which is as follows:

$$\mathrm{Y}_t = (A_t H_t)^{1-ak} {K_t}^{ak}$$

The utility function used in this study is standard in the business cycle literature, as follows:

$$U(c,l) \; = \; log\; c + \psi log(1-h)$$

Simulation steps

- Calibrate the model using data in 1995

- Obtain the first order conditions of the basic model

- Assume perfect foresight as McGrattan and Prescott (2010) to allow non-linear process.

Simulation steps

- Instead of using log-linearization approach, non-linear approach is used. That is, directly obtain TFP shocks from data without log-linearization.

- Simulate using TFP and government purchase shocks.

Basic model predictions

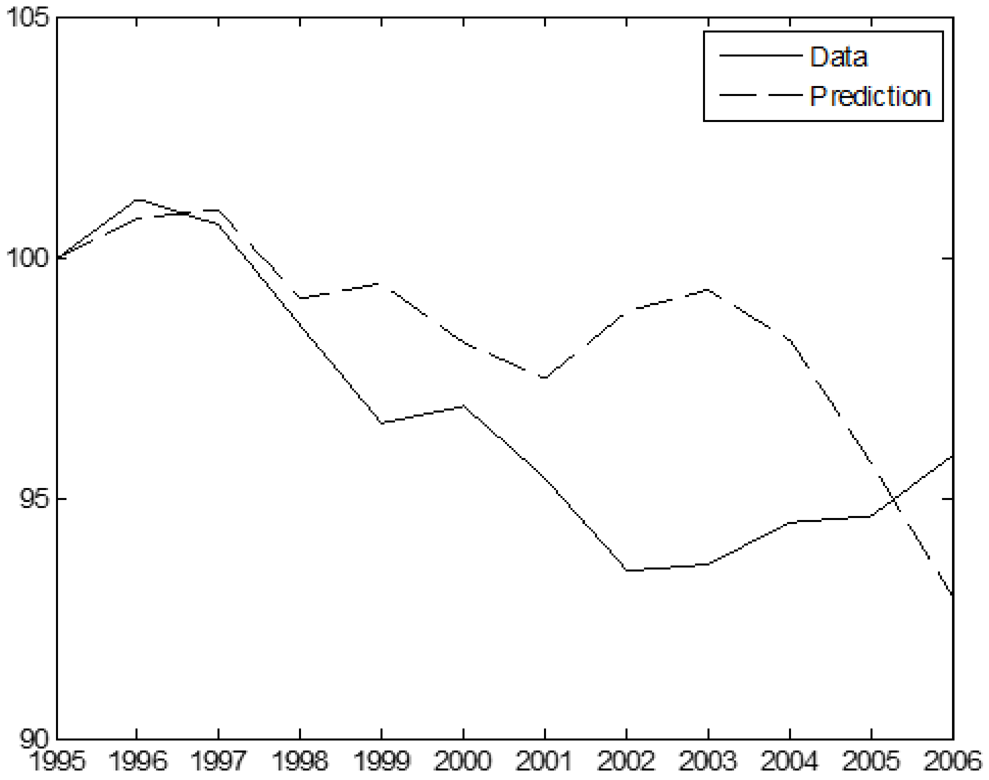


Figure 1. Japan and basic model per capita hours worked
(Annual, 1995=100, 1995-2006)

Basic model predictions

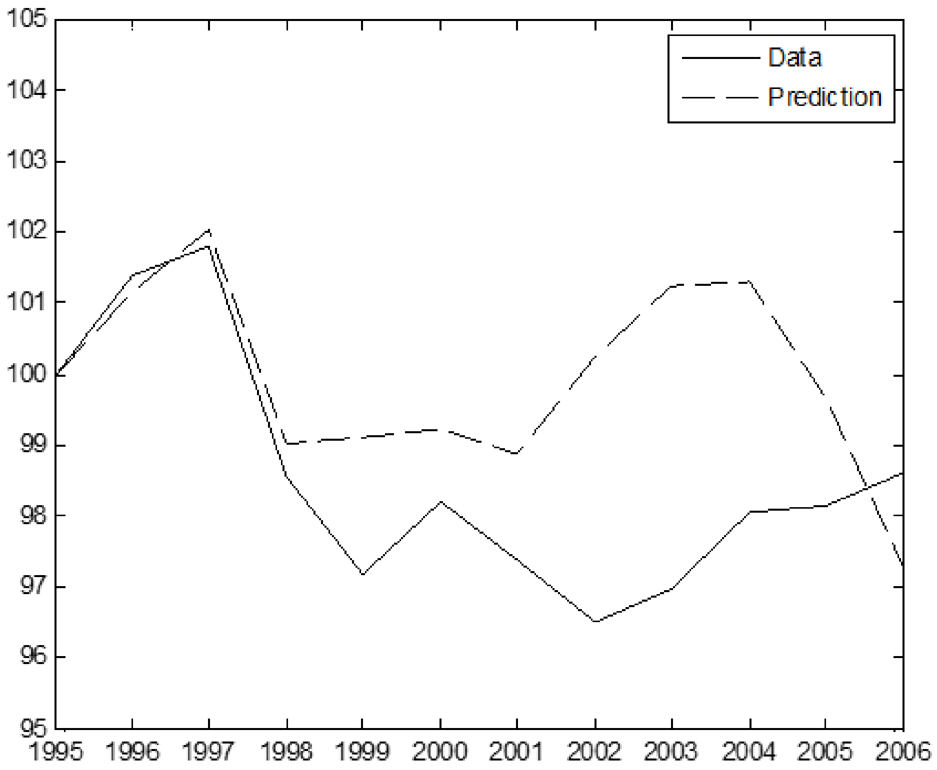


Figure 2. Japan and the basic model real GDP per capita
(Detrended by 1.015^t, annual, 1995=100, 1995-2006)

Basic model predictions

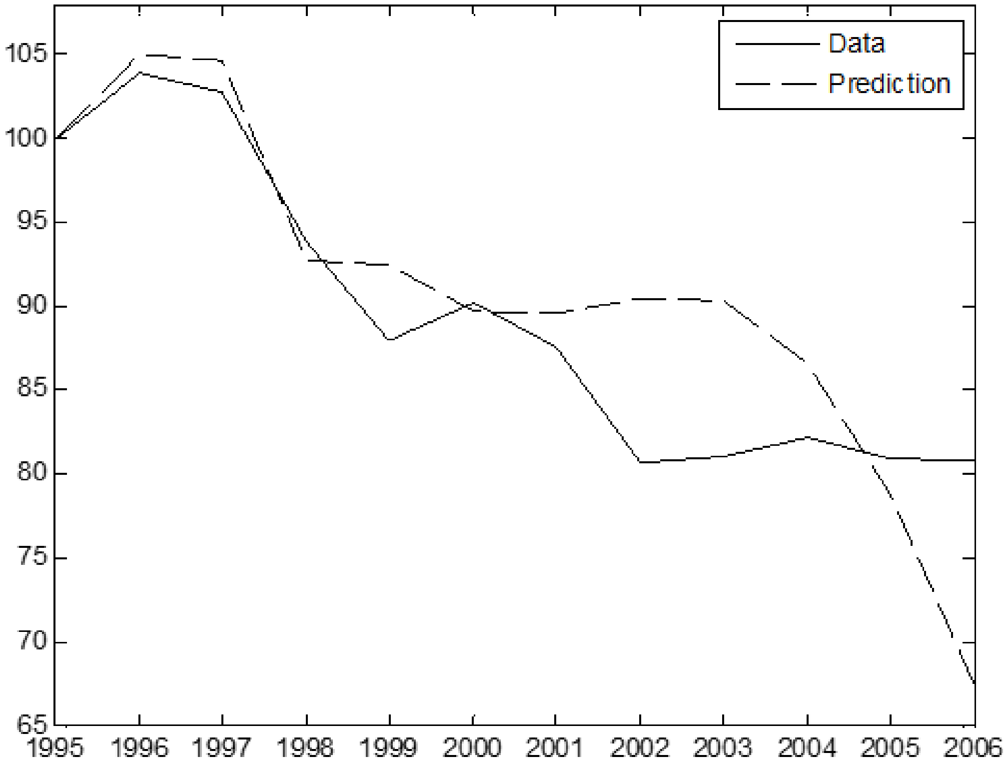


Figure 3. Japan and the basic model tangible investment per capita
(Detrended by 1.015^t, annual, 1995=100, 1995-2006)

Basic model predictions

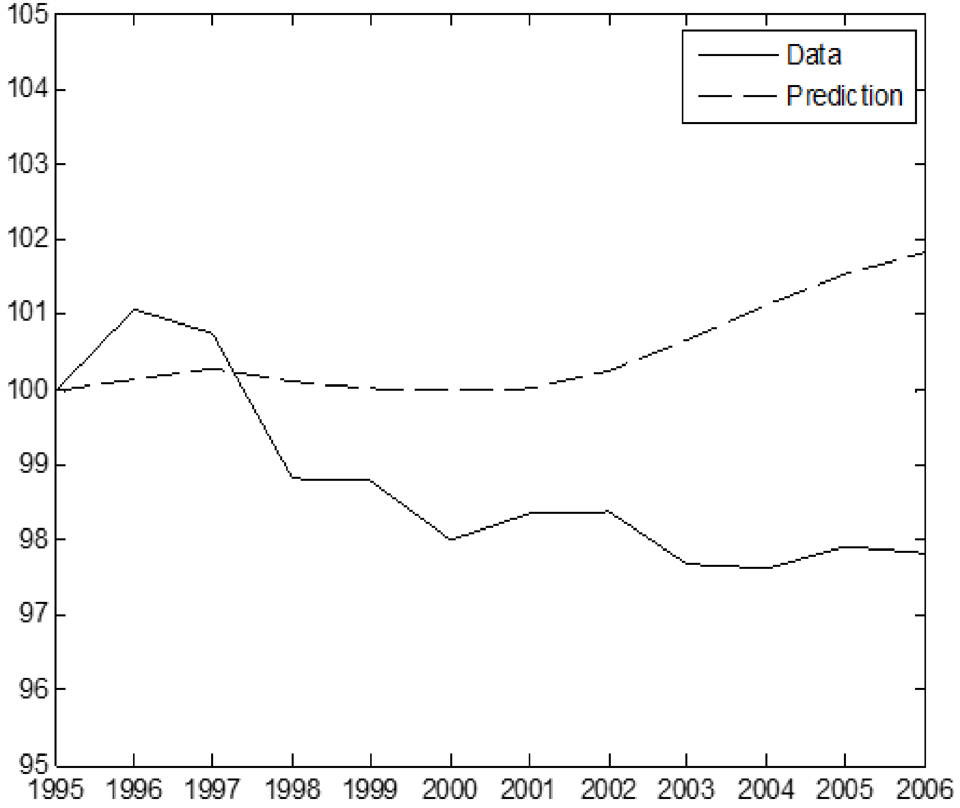
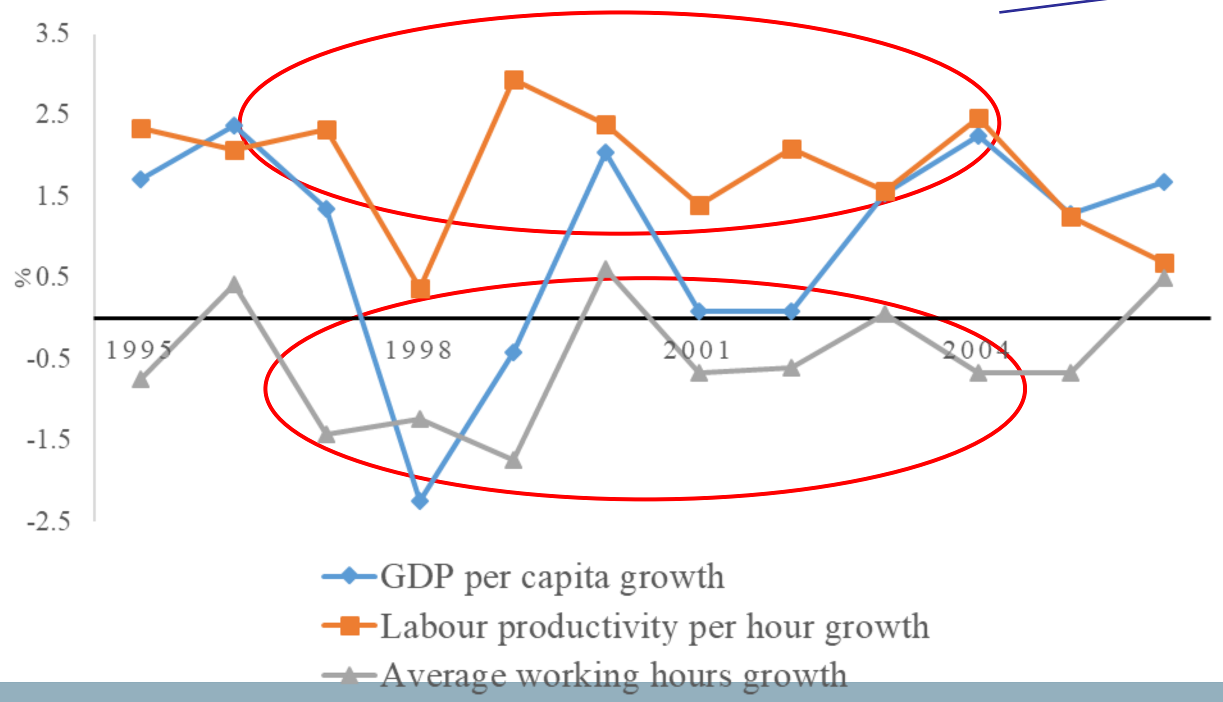


Figure 4. Japan and the basic model consumption per capita
(Detrended by 1.015^t, annual, 1995=100, 1995-2006)

Evidence of decreased intangible investment

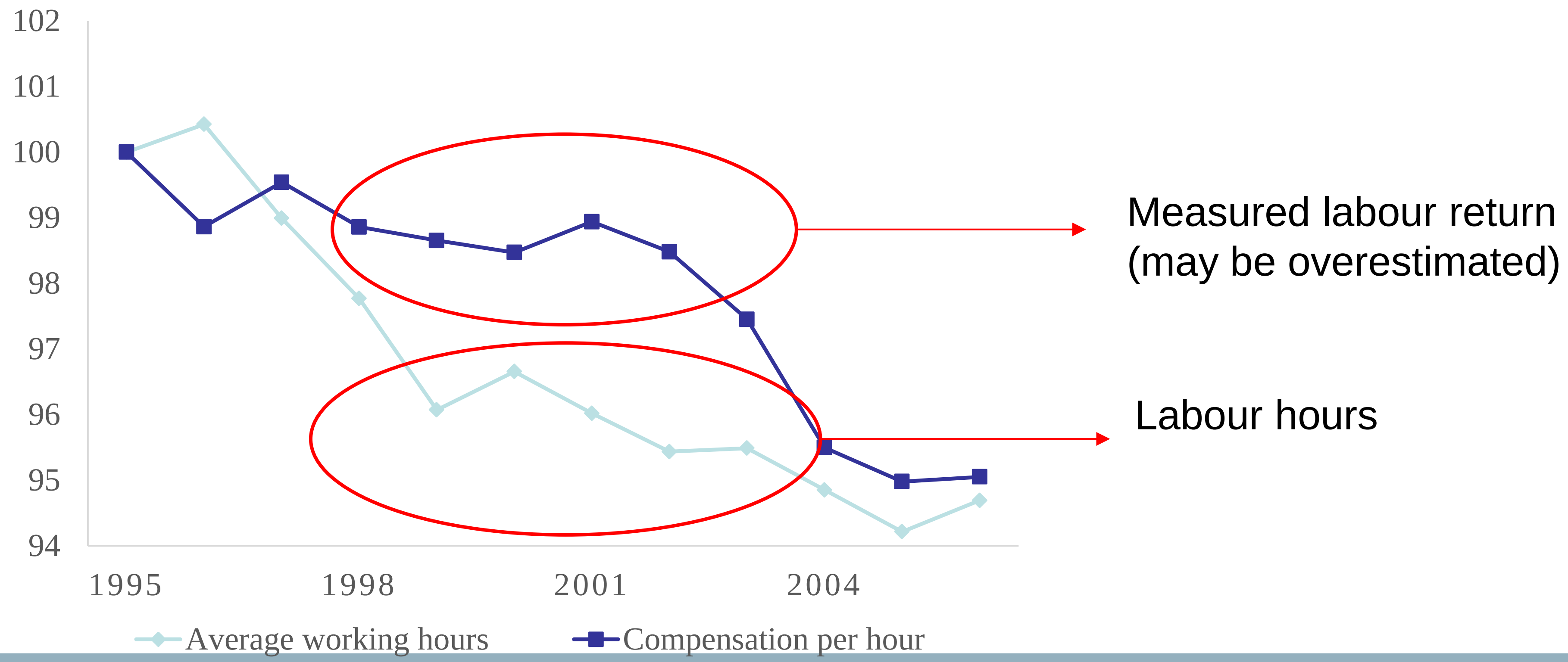
If all incomes were included in national accounts, we would expect both the growth rate of labour productivity per hour and the growth rate of output to be low during a depression.

May be overestimated?



Evidence of decreased intangible investment

The compensation per hour remained stable while the working hours per labour declined, which may indicate that the unmeasured investment was low in many years.



Extended model

The maximization problem of household is

$$\mathrm{E}_0[\sum_{t=0}^{\infty} \beta^t U(c_t, h_t) N_t],$$

subject to

$$c_t + x_{Tt} + q_t x_{It} = \boxed{(1 - t_{wt})} w_t h_t + r_{Tt} k_t + r_{It} k_{It} + T_t.$$
$$k_{T,t+1} = \left[(1 - \delta_T) k_{T,t} + x_{Tt}\right] / (1 + n)$$
$$k_{I,t+1} = \left[(1 - \delta_I) k_{I,t} + x_{It}\right] / (1 + n)$$

Effective labour income tax rate
(Labour market frictions)

Extended model

The aggregate production comprises two aggregation production relations:

$$y_t = (\boxed{A_t^1} h_t^1)^{1-ak-ai} (k_{Tt}^1)^{ak} (\boxed{k_{It}})^{ai}$$
$$x_{It} = (\boxed{A_t^2} h_t^2)^{1-ak-ai} (k_{Tt}^2)^{ak} (\boxed{k_{It}})^{ai}$$

Labour and physical capital are allocated between two activities

Non-neutral technology: Productivity differs in two activities

Intangible capital can be simultaneously used in two activities, e.g. brand and R&D.

Explaining the seemingly high wages

The basic model measures the real wage as

$$\bar{w}_t = (1 - ak)\frac{y_t}{(h_t^1 + h_t^2)}$$

The real wage measurement should be

$$w_t = (1 - ak - ai)\frac{y_t}{h_t^1}$$

If the relative size of h_t^2 to $h_t^1 + h_t^2$ decreases, then $\bar{w}_t / w_t$ increases and the difference between measured wage and true wages becomes more significant, i.e. the measured wage is more overestimated.

Identifying total factor productivities

To identify how much labour is allocated to the two production activities, I use the fact that the after tax real wage rate equals the marginal rate of substitution between leisure and consumption, following McGrattan and Prescott (2010). That is,

$$h_t^1 = (1 - t_{wt})\frac{(1 - ak - ai)\hat{y}_t}{\psi \hat{c}_t}(1 - h_t)$$

Identifying total factor productivities

Then, intangible investment is derived from the model. As per McGrattan and Prescott (2010), the derivation of intangible investment relies heavily on theory and observations on consumption, total working hours, final goods and services as well as labour tax rate.

This method has an advantage over direct measurement when some or all of the intangible investment is not or cannot be measured (accurately) due to data availability issues.

Model predictions of the extended theory

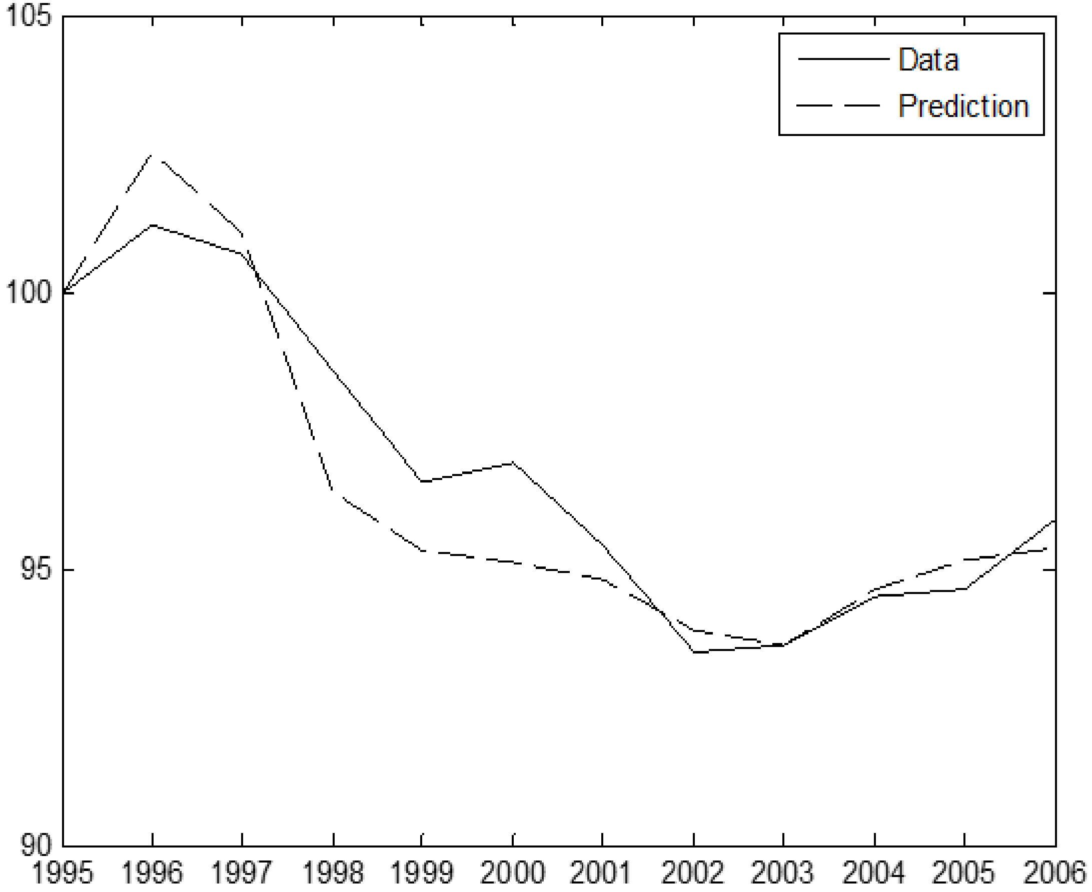


Figure 8. Extended model per capita total hours worked in Japan
(Annual, 1995=100, 1995-2006)

Model predictions of the extended theory

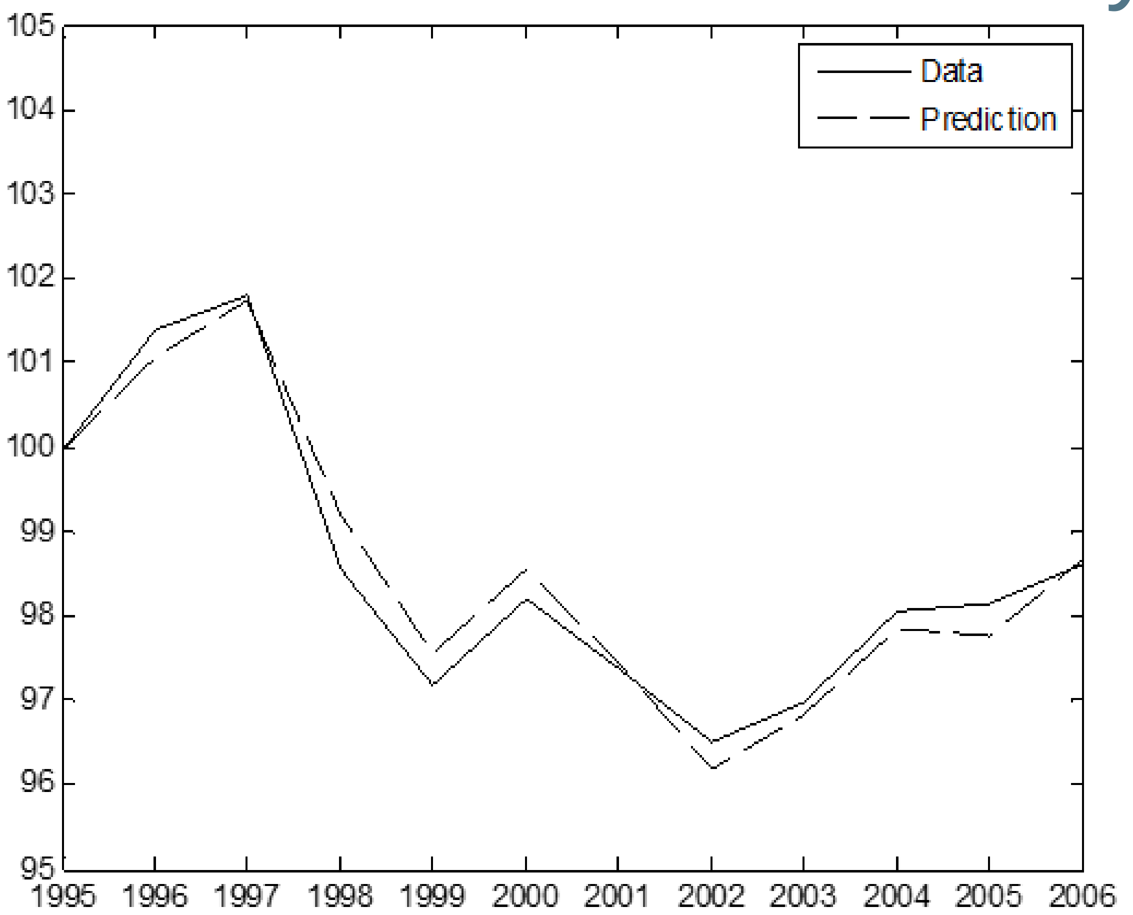


Figure 9. Extended model per capita real GDP in Japan
(Annual, series detrended by 1.015^t, 1995=100, 1995-2006)

Model predictions of the extended theory

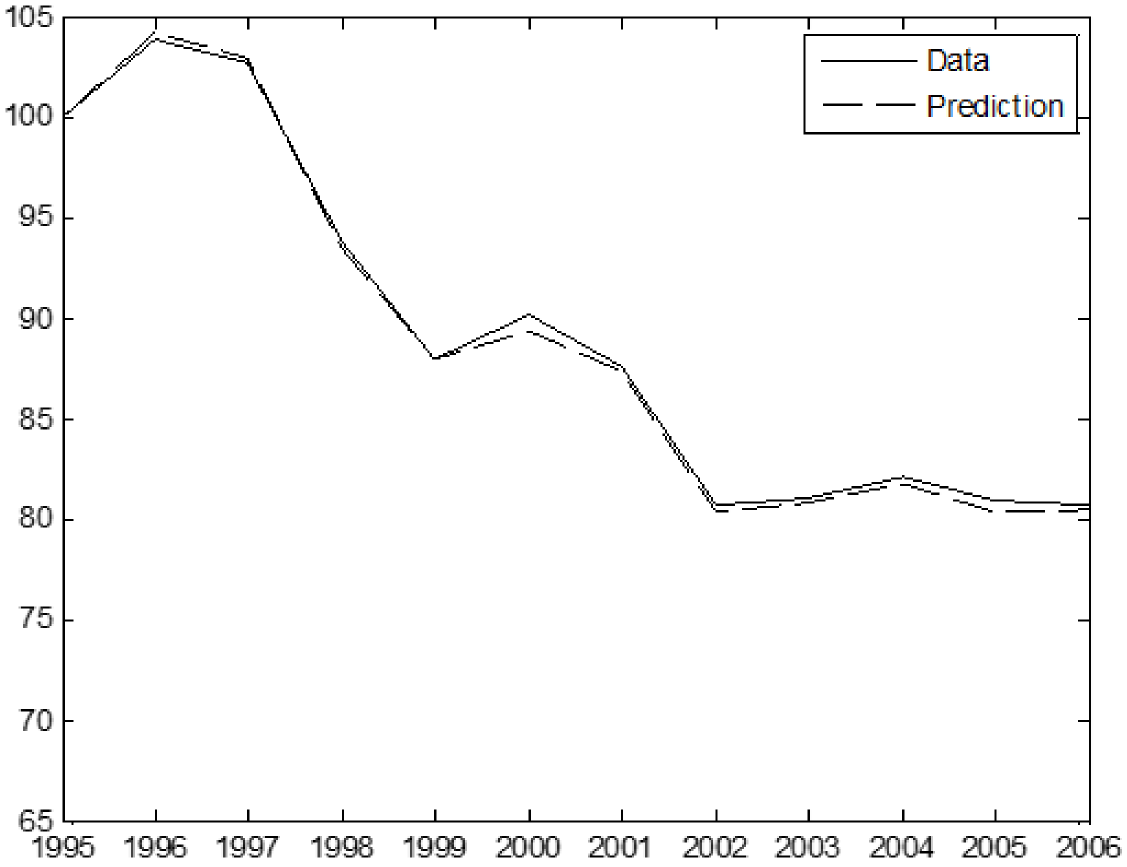


Figure 10. Extended model per capita tangible investment in Japan
(Annual, series detrended by 1.015^t, 1995=100, 1995-2006)

Model predictions of the extended theory

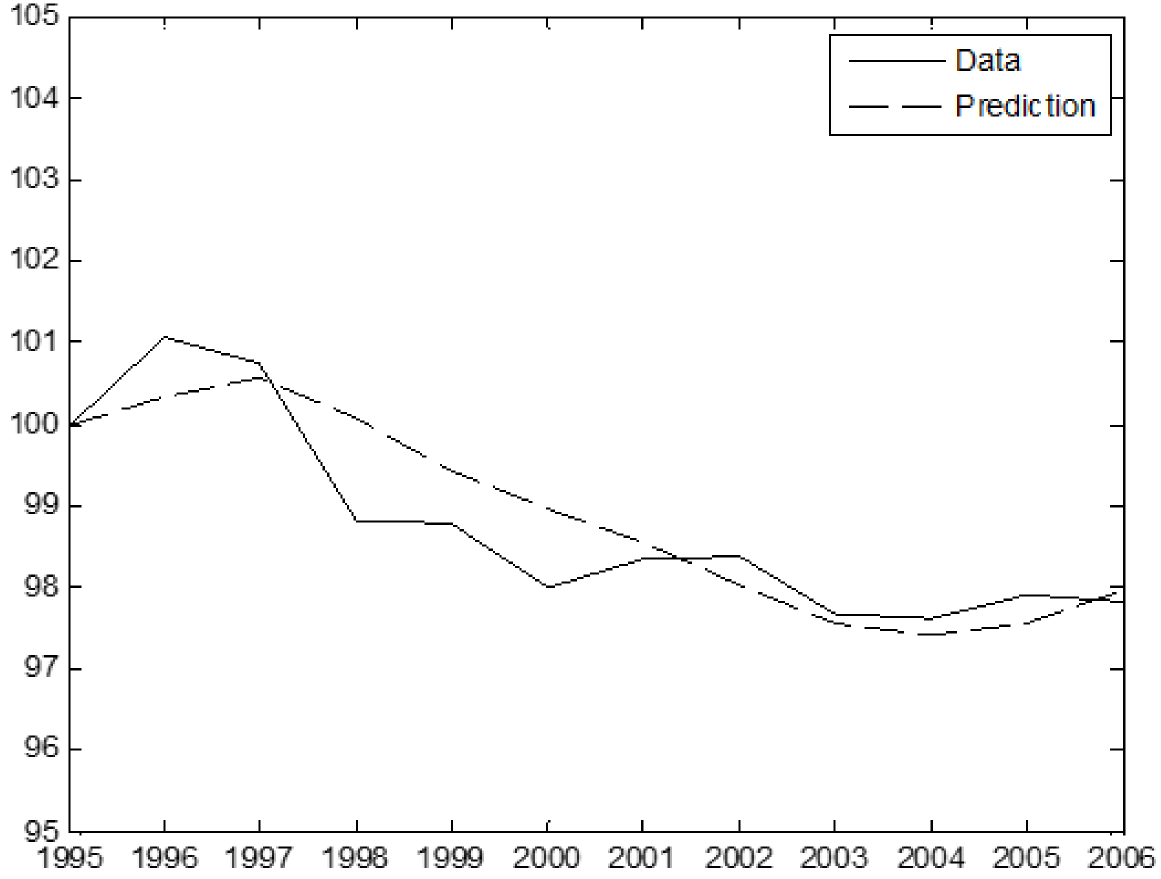


Figure 11. Extended model per capita consumption in Japan
(Annual, series detrended by 1.015^t, 1995=100, 1995-2006)

Model predictions of the extended theory

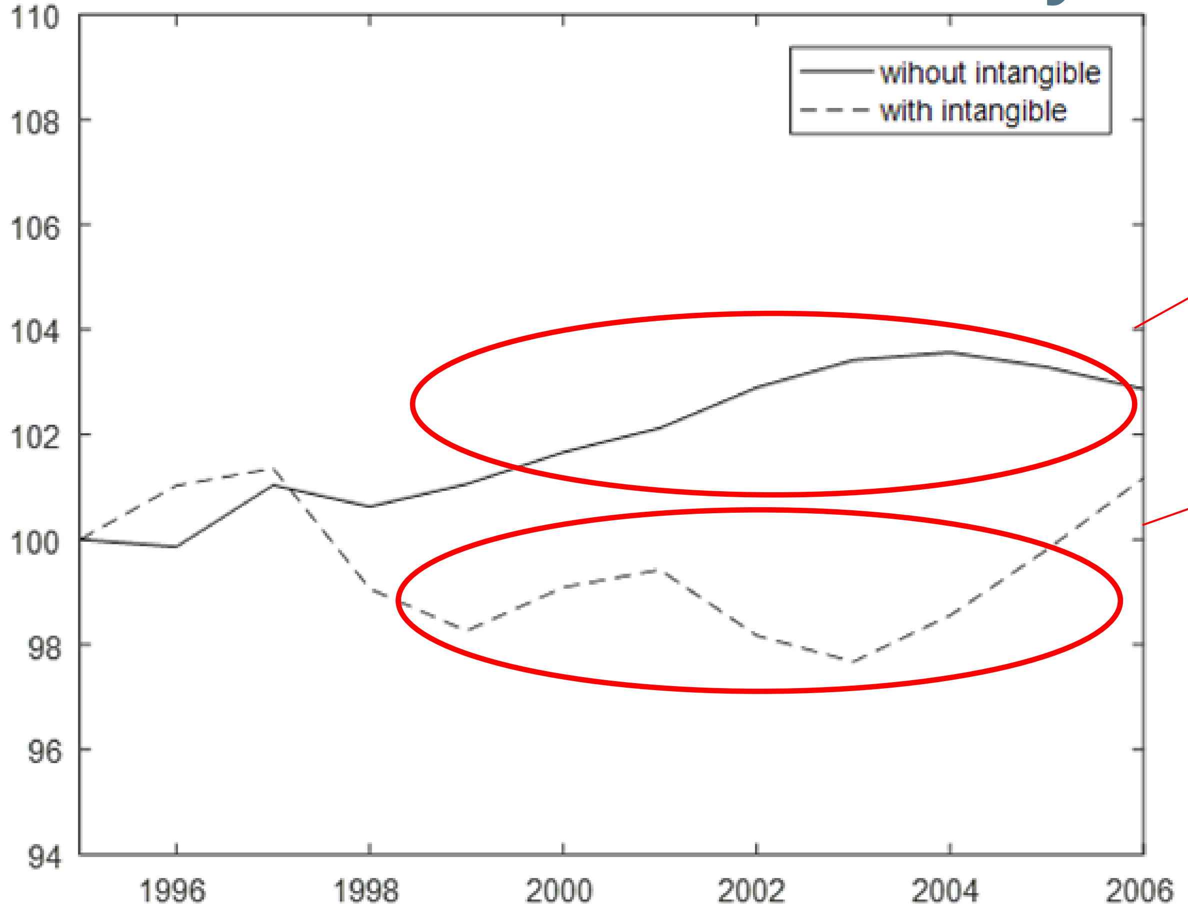


Figure 12. Extended model labour productivity in Japan
(Annual, series detrended by 1.015^t, 1995=100, 1995-2006)

Measured labour productivity

Actual labour productivity

The decline in productivity is underestimated.

Model predictions of the extended theory

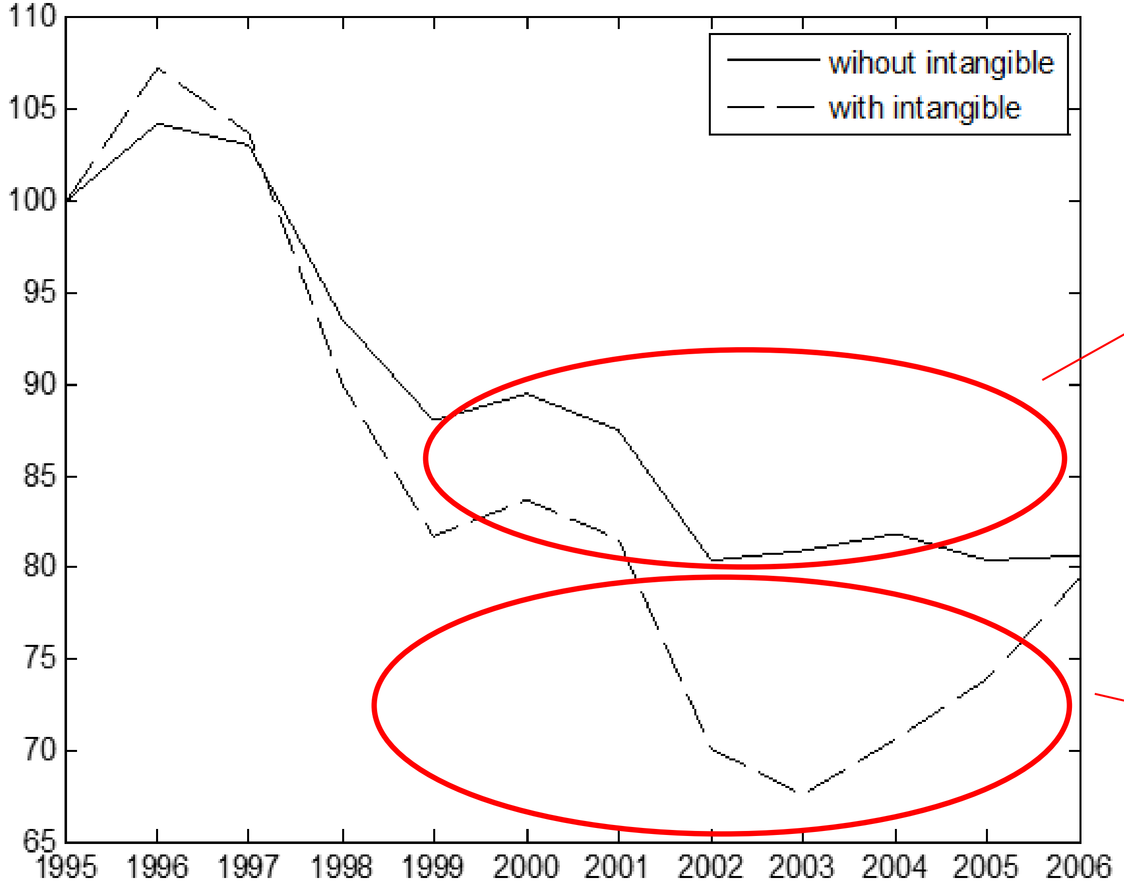


Figure 13. Extended model per capita investment in Japan (Annual, series detrended by 1.015^t, 1995=100, 1995-2006)

Measured investment

The decline in investment is also underestimated.

Actual investment

Results with alternative model settings

- In this section I test the robustness of the extension developed by McGrattan and Prescott (2010) with an alternative model with tangible investment adjustment costs.

- Christiano and Davis (2006) indicate that introducing tangible investment adjustment costs can affect the prediction results of neoclassical growth models.

Results with alternative model settings

In both the basic model and the extended model, the law of the motion of tangible capital turns into

$$\hat{k}_{t+1} = \left[(1-\delta)\hat{k}_t + \hat{x}_t \boxed{- \Phi\left(\frac{\hat{x}_t}{\hat{k}_t}\right)\hat{k}_t}\right]/(1+n)$$

Tangible capital adjustment costs

where

$$\Phi\left(\frac{\hat{x}_t}{\hat{k}_t}\right) = \frac{\phi}{2}\left(\frac{\hat{x}_t}{\hat{k}_t} - \lambda_T\right)^2$$

Results with alternative model settings

Results remain robust.

The basic alternative model fails to generate satisfying predictions and the extended alternative model improves the predictions significantly.

Conclusion

- The unmeasured intangible investment as well as non-neutral technological change in intangible investment production led to the puzzling behaviour of the Japanese economy between 1995 and 2006.

- This change resulted in a depression in intangible investment, which is not reflected in the measured output.

Calibration

Table A1 Model parameters

Parameter	**Expression**	**Value**
Common parameters		
Growth in population	n	-0.003
Growth in technology	γ	0.015
Discount factor	β	0.98
Standard model, no intangible investment		
Utility parameter	ψ	4.44
Depreciation rate	δ	0.07
Capital share	ak	0.35
Extended model, with intangible investment		
Utility parameters	ψ	3.43
Tangible depreciation rate	δ_T	0.07
Intangible depreciation rate[1]	δ_I	0
Tangible capital share	ak	0.3276
Intangible capital share	ai	0.2064