News about technology, endogenous diffusion and economic fluctuations

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Motivation

- Are shocks about future technology expansionary? If so, how?
  - How should we model shocks to future technology?
  - What are the mechanisms that propagate these shocks?
- Are these shocks important to explain business fluctuations?
  - Is IR able to generate statistically sound macro time series?
  - Unconditionally, do shocks-model account for a significant share of fluctuations in key variables?

Motivation: Contributions

- Beveridge (1909), Pigou (1927), Clark (1934): news about the future can drive business fluctuations
- Empirical evidence:
  - The second half of the 90s: 1994-1995, emergence of VC, # of patents, internet,... companies that become public at the end of the decade. Large productivity growth 1995-2000
  - Stock prices and consumer confidence lead the business cycle (Stock and Watson (1999))
  - Innovations to stock prices orthogonal to current TFP growth are correlated to future TFP growth (Beaudry and Portier (2006)).

Theoretical problem

- In a standard RBC model, news about future technology are contractionary.
- Future high productivity causes a wealth effect.
- Since current technology does not increase, there is no substitution effect that induces agents to invest more or work harder.
- On the contrary, expectations about future wealth lead agents to consume more today and contract labor supply causing a recession.

Fixes

- Beaudry and Portier (2004): Two complementary consumption goods, one durable and one non-durable. Both goods are produced with labor and a fixed production factor. Labor is sector-specific. $\uparrow C \Rightarrow \uparrow I \Rightarrow L$ has to $\uparrow$
- Rebelo and Jaimovich (2006): Play with utility function. The shock is not such good news since it makes so much harder to work in the future. Crash in the market.
- Christiano, Motto and Rostagno (2007): Adjustment costs (want to start increasing I now) and habit (do not want to $\uparrow$ C too much). L can initially $\uparrow$, but large drop in L when shock is realized (because wealth effect kicks in).

Our Framework

- Technology that diffuses endogenously and slowly:
  - Very natural notion of news about future technology.
  - Speed of technology diffusion is pro-cyclical (Comin, 2007).
- Variable capacity utilization and entry.

As a result, endogenous relative price of capital

We find

- If technology adoption is exogenous, recession in response to news about future technology.
- By endogenizing technology adoption we obtain a boom in response to future technology boom.
- Intuition:
  - Profitable opportunities to adopt new technologies.
  - To take advantage of these, they need to invest today in adoption.
  - To pull the extra resources they need higher output
  - This raises today's demand for labor and capital generating a boom

Quantitative Analysis

- Calibrations: a shock that generates an increase in output growth of 0.5 percentage points leads to a 1.6 percent increase in output upon impact of the news.
- We estimate a richer model with 4 other shocks, adjustment costs and habit and find that shocks about news account for 45% of output growth, 35% of hours growth, 93% of investment growth and 88% of consumption growth.
- Introducing nominal rigidities increases share of output variance accounted to 54%.

Model - Final output

$$Y_t = [\int_0^{N_t} Y_t(j)^{\frac{1}{\mu_t}} dj]^{\mu_t}$$

$$Y_t(j) = X_t L_t(j)^{1-\alpha} (U_t(j) K_{t-1}(j))^{\alpha}$$

$$X_t = (1+g) X_{t-1} \exp^{\varsigma_t}$$

Model - Investment

$$K_t = (1 - \delta(U_t))K_{t-1} + J_t$$

$$J_t = \left(\int_0^{N_t^K} J_t\left(r\right)^{\frac{1}{\mu_t^K}} dr \right)^{\mu_t^K}$$

$$J_t\left(r\right) = \left(\int_0^{A_t^a} I_t^r(s)^{\frac{1}{\theta}} ds \right)^{\theta}, \text{with } \theta > 1.$$

Model - Technology

$$Z_{t+1} = (\chi_t + \phi) Z_t$$

$$\chi_t = \rho \chi_{t-1} + \varepsilon_t$$

$$A_t = \lambda_t [Z_{t-1} - A_{t-1}] + \phi A_{t-1}$$

$$\lambda_t = \lambda(\Gamma_t x_t)$$

with $\lambda' > 0$, $\lambda'' < 0$,

$$\Gamma_t = Z_t / (1 + g_y)^t$$

Model - Value of innovation and optimal adoption

$$v_t = \pi_t + (1-\phi)E_t\left[\frac{v_{t+1}}{R_{t+1}}\right].$$

$$w_t = \max_{x_t} -x_t + E_t\left[\frac{\phi}{R_{t+1}}\left[\lambda_t v_{t+1} - (1-\lambda_t)w_{t+1}\right]\right]$$

$$1 = E_t\left[R_{t+1}^{-1}\Gamma_t\phi\lambda'\left(\Gamma_t x_t\right)\left(v_{t+1} - w_{t+1}\right)\right]$$

Model - Free entry

$$\frac{\mu - 1}{\mu}\frac{Y_t}{N_t} = b(1 + g_y)^t$$

$$\frac{\mu_k - 1}{\mu_k}\frac{P_t^K J_t}{N_t^K} = b_K(1 + g_y)^t$$

Model - Households

$$Max\ E_t \sum_{i=0}^{\infty} \beta^{t+i} e^{\mu^b_{t+i}} \left[\ln C_t - e^{\mu^w_t} \frac{(L_t)^{\zeta+1}}{\zeta+1} \right]$$

s.t.

$$\begin{aligned} & C_t + q_t(K_t - K_{t-1}) + x_t(Z_t - A_t) + G_t \\ = \ & \omega_t L_t + r_t K_{t-1} + \pi_t A_t + w_t(Z_t - Z_{t-1}) + v_t(A_t - A_{t-1}) \end{aligned}$$

where

$$\begin{aligned} \mu^w_t &= (1-\rho^w)\mu^w + \rho^w \mu^w_{t-1} + \epsilon^w_t \\ \mu^b_t &= (1-\rho^b) + \rho^b \mu^b_{t-1} + \epsilon^b_t \\ G_t &= (1+g_y) G_t \exp^{\epsilon^g_t} \end{aligned}$$

Stock Market vs. relative price of capital

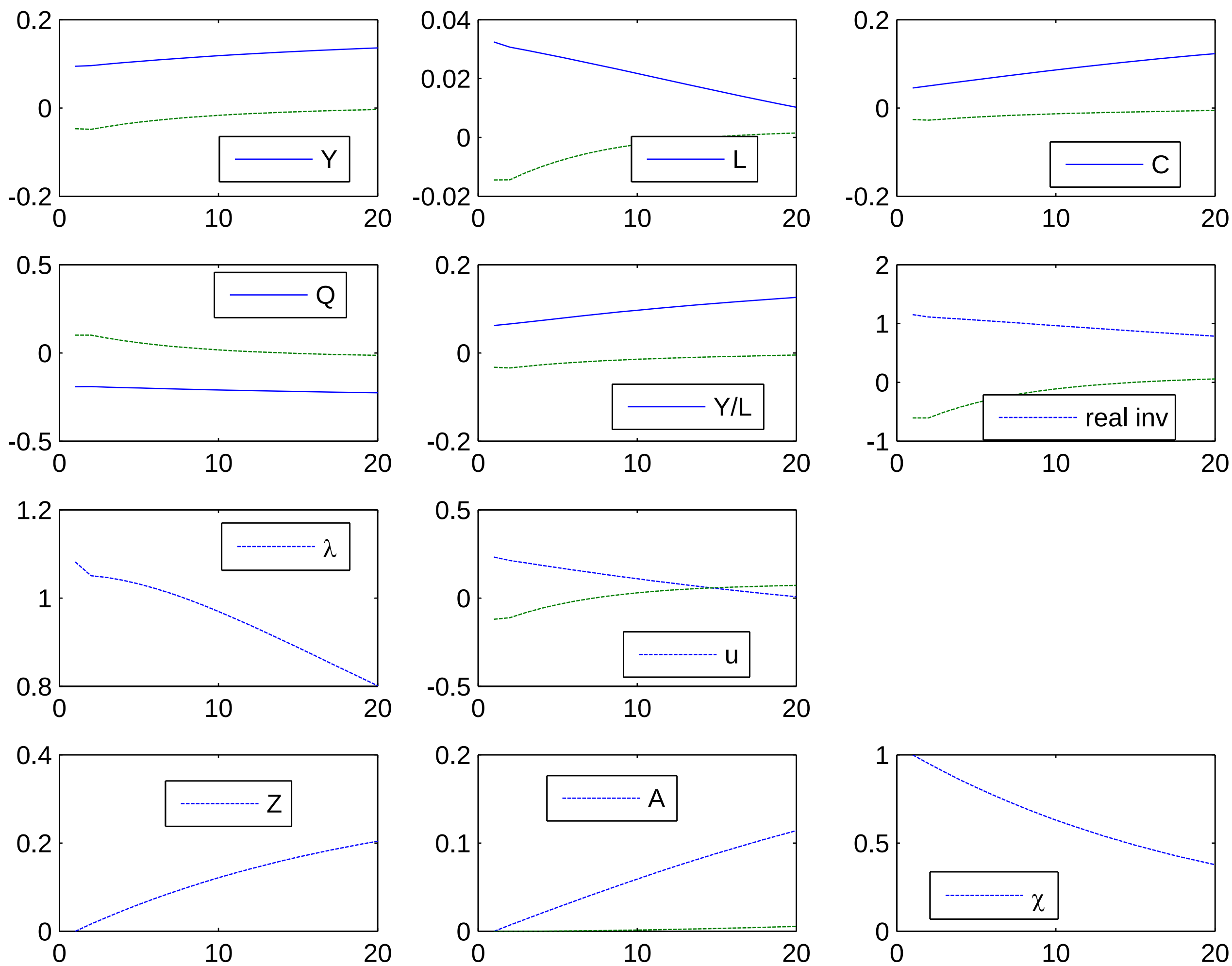
$$q_t = \mu_K \theta \left(N_t^K\right)^{-(\mu_k - 1)} A_t^{-(\theta-1)}$$

$$\begin{aligned} S_t &= q_t K_t + \varphi \Big[A_t(v_t - \pi_t) + (w_t + x_t)(Z_t - A_t) \\ &\quad + E_t \sum_{\tau=t+1}^{\infty} \left(\Pi_{s=t+1}^{\tau} R_s^{-1}\right) w_\tau (Z_\tau - \phi Z_{\tau-1})\Big] \end{aligned}$$

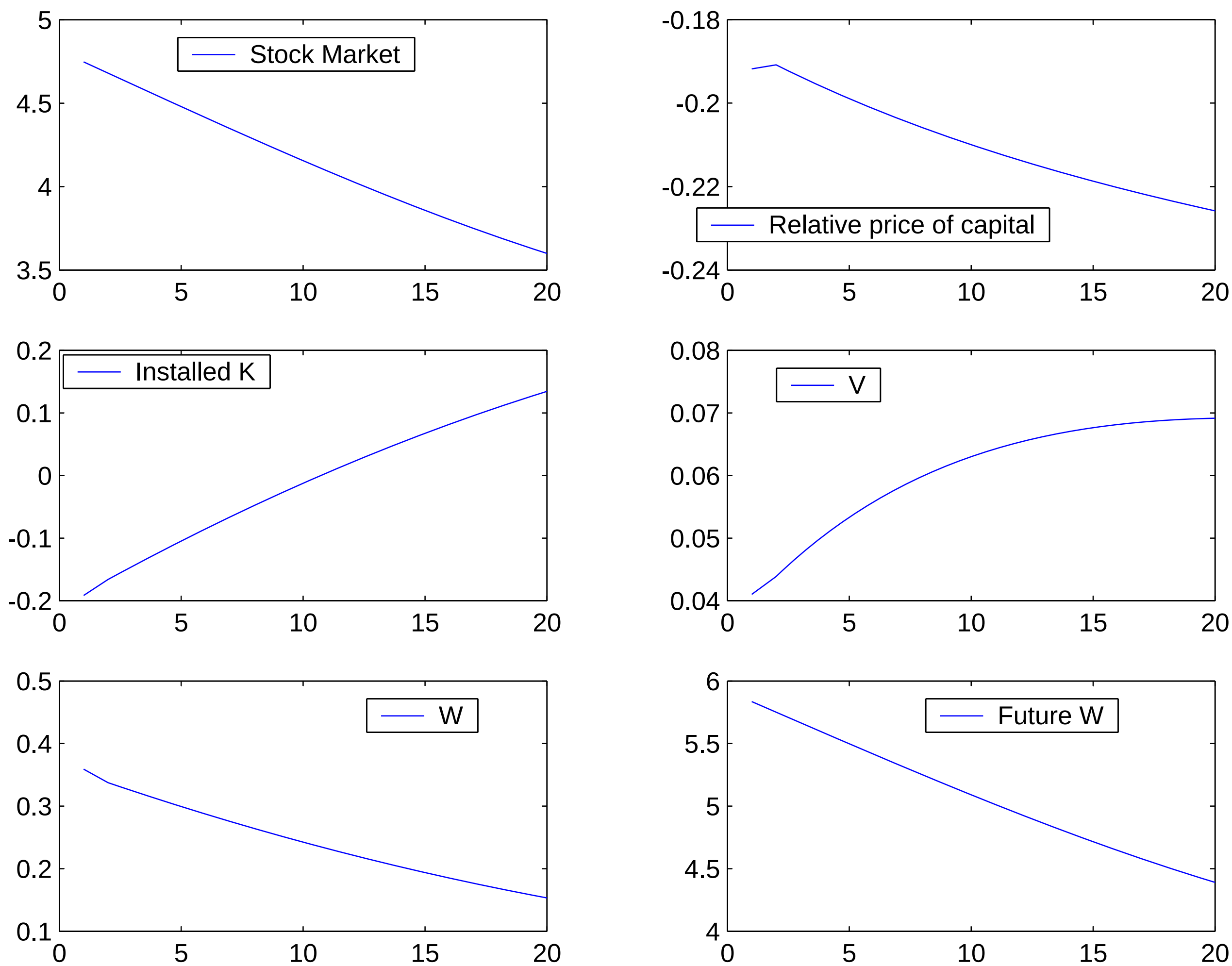
Calibration

parameter	Value
$\frac{\lambda^{'}x}{\lambda}$	0.85-0.9
$\frac{\delta'^{'}U}{\delta'^{'}}$	0.15
$[\zeta]$	1
μ_w	1.2
μ	1
$b,\ b_K$	$OC \simeq .1 * Y,\ N = N_K = 1$

Table: Calibrated Parameters



Y
L
C
Q
Y/L
real inv
λ
u
Z
A
χ

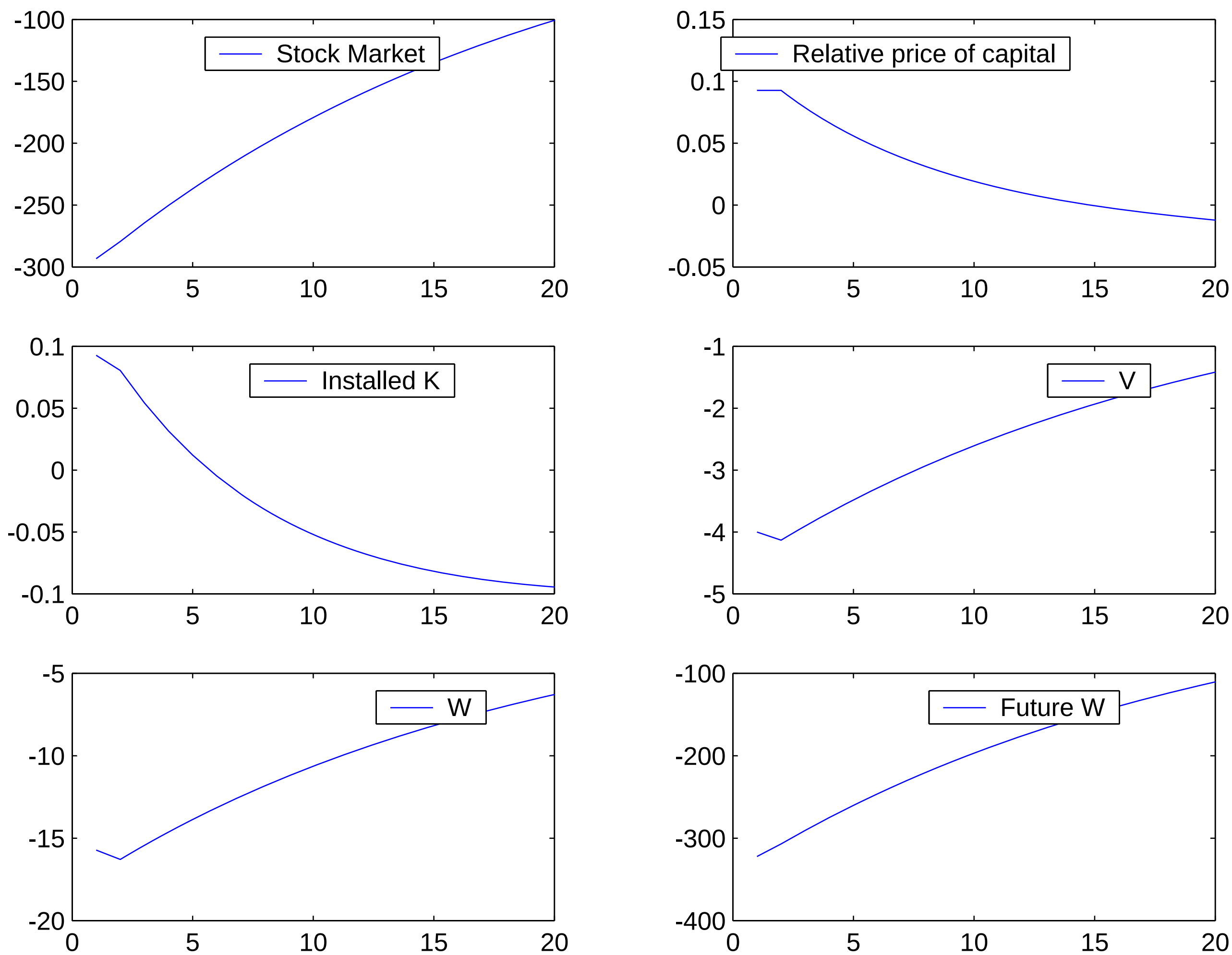


Stock Market
Relative price of capital
Installed K
V
W
Future W

Model without endogenous adoption

Two ways to think about model without endogenous adoption

- Standard RBC model: future technology is just a current increase in Z_t that slowly leads to higher A_t
  - No endogenous adoption
  - No v_t or w_t or π_t
- Adopted intermediate goods arrive exogenously in the future:
  - No endogenous adoption
  - v_t and π_t are well defined and w_t is the shadow value of an unadopted intermediate good



Stock Market
-100
-150
-200
-250
-300
0
5
10
15
20
Relative price of capital
0.15
0.1
0.05
0
-0.05
Installed K
0.1
0.05
0
-0.05
-0.1
V
-1
-2
-3
-4
-5
W
-5
-10
-15
-20
Future W
-100
-200
-300
-400

Quantitative significance

- A shock about future technology which leads to an annual increase of 0.5 percentage points in the growth rate over the next five years leads to a increase in GDP of 1.58 percent upon impact.

Bayesian estimation

- Bayesian estimation is a bridge between calibration, through the specification of priors, and maximum likelihood, confronting model with data.
- Advantages of Bayesian estimation:
  - fits the complete DSGE model to a vector of time series rather than particular equilibrium relationships
  - Based on the likelihood function generated by the DSGE system rather than discrepancy between DSGE and VAR IRs
  - Allow for the use of priors that act as weights in the estimation process.
  - Addresses model misspecification by adding shocks interpreted as observation errors in the structural equations

Dynare

- We use Dynare (Juillard 1996) to estimate the model.
- Dynare estimates in the following way:
  - it estimates the likelihood of the DSGE solution system using the Kalman filter.
  - it uses the priors and the estimated likelihood function to obtain the posterior distribution (posterior kernel).
  - The posterior kernel obtained before is nonlinear in the parameters. Dynare uses a Metropolis-Hastings algorithm to simulate the posterior distribution of the parameters.

Robustness

- Investment adjustment costs

$$K_t = (1 - \delta(U_t))K_{t-1} + I_t \left(1 - \gamma \left(\frac{I_t}{(1 + gy - gq)I_{t-1}} - 1\right)^2\right)$$

- Habit

$$\tilde{C}_t = C_t - hC_{t-1}$$

Data

- Sample: 1954:III to 2004:IV
- Output growth: Real GDP per capita
- Consumption growth: Real consumption (personal consumption expenditures of non-durables and services)
- Hours: Hours in the non-farm business sector divided by population
- Investment growth: Real investment (personal consumption of durables and gross private domestic investment)
- Real interest rate: federal funds rates deflated by GDP deflator

Exogenous shocks

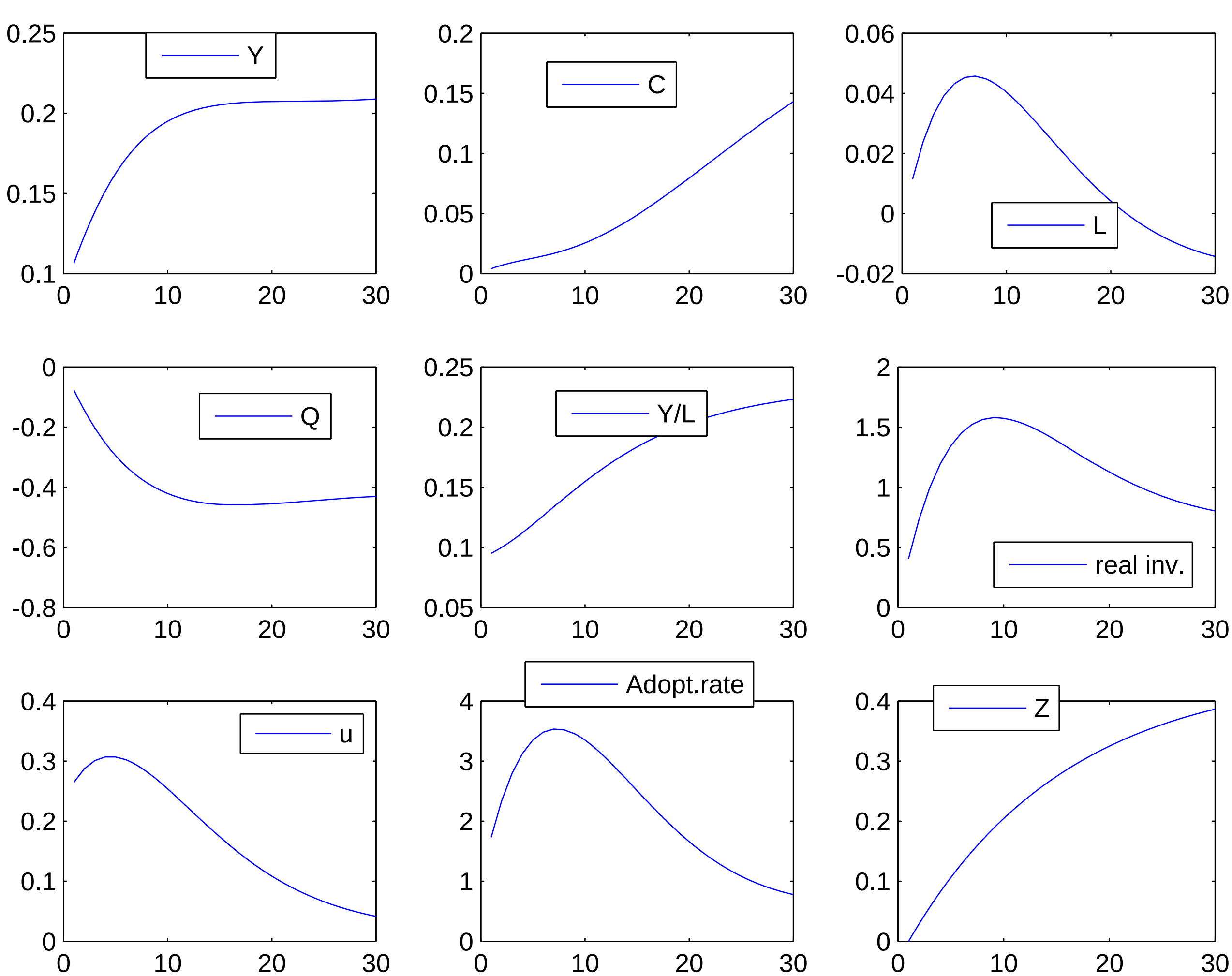
- Shock to the discount factor
- TFP shock: stationary TFP with deterministic trend
- Shock to the arrival of new technologies
- Labor supply shock
- Government spending

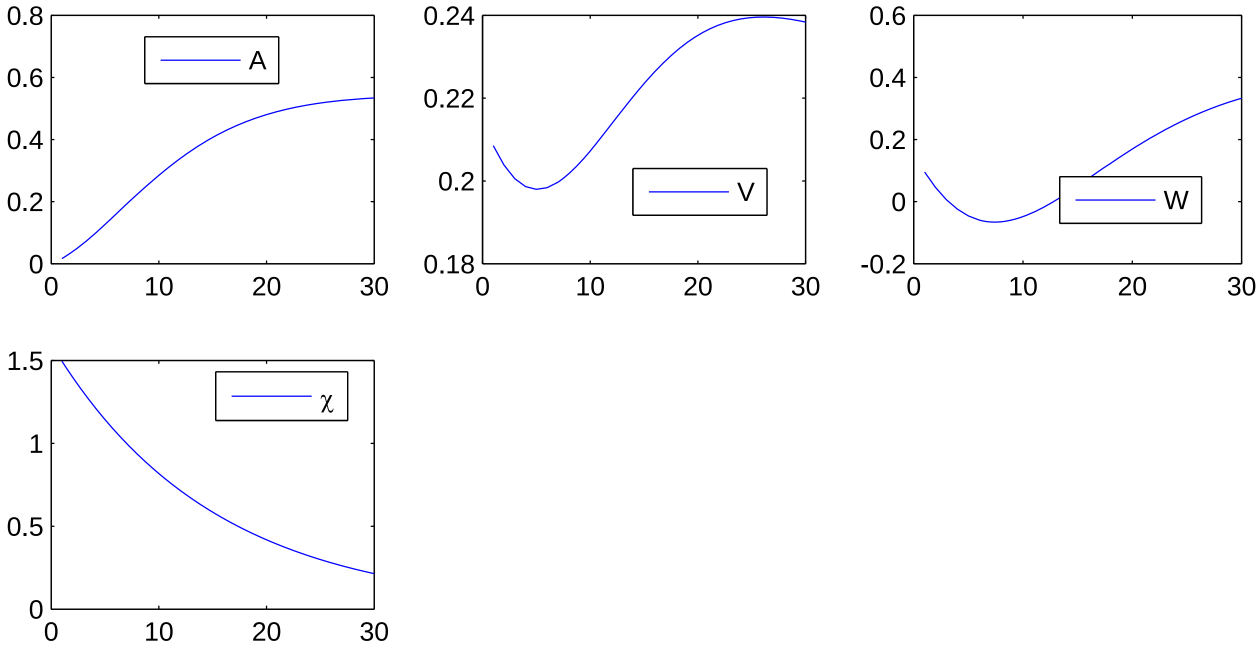
parameter	prior distribution	prior mean	prior standard deviation
h	beta-pdf	0.5	0.1
ddac	normal-pdf	2	1.5
fi	gamma-pdf	1	0.75
edp	gamma-pdf	0.2	0.75
rhob	gamma-pdf	0.5	0.15
rhok	gamma-pdf	0.5	0.15
rhow	gamma-pdf	0.5	0.15
rhordi	gamma-pdf	0.5	0.15
stderr echird	inv-gamma-pdf	0.1	∞
stderr eb	inv-gamma-pdf,	0.15	∞
stderr ek	inv-gamma-pdf	0.15	∞
stderr ew	inv-gamma-pdf	0.15	∞

Table 2: Priors estimated parameters

parameters	post. mean	95 percent	5 percent
h	0.87	0.79	0.93
ddac	2.1	2.04	2.14
fi	0.04	0.038	0.042
edp	0.0001	0.0001	0.0001
rhob	0.74	0.73	0.75
rhotfp	0.35	0.34	0.36
rhow	0.0069	0.0040	0.0101
rhordi	0.9940	0.9944	0.9946
rhog	0.7645	0.7608	0.7682
echird	0.22	0.20	0.24
emuw	0.46	0.44	0.47
emug	0.7085	0.69	0.72
emuc	0.60	0.59	0.62
etfp	0.66	0.64	0.67

Table 3: Posterior estimated parameters


Y
C
L
Q
Y/L
real inv.
u
Adopt.rate
Z



A
V
W
χ
0.8
0.6
0.4
0.2
0
0.24
0.22
0.2
0.18
0.6
-0.2
1.5
1
0.5
10
20
30

Variance Decomposition

Observable variable	μ_w	μ_b	μ_{rd}	TFP	g
ΔL_t	32.97	0.09	34.83	31.90	0.22
R	54.20	5.21	30.16	10.40	0.04
ΔY_t	36.80	4.37	44.94	12.54	1.35
ΔI_t	0.01	0.14	93.18	6.65	0.02
ΔC_t	5.27	1.82	87.95	4.90	0.05

Table: Variance Decomposition (in percent)

Model with nominal rigidities

- Price setting a la Calvo with partial indexation
- Taylor rule for the determination of nominal interest rate

Estimation

- Lower labor supply elasticity
- Higher elasticity of utilization
- Lower adjustment costs.

Conclusions

- Importance of endogenous technology (adoption) to understand business cycle dynamics.
- News about future technologies can be a significant source of fluctuations once we recognize that technologies diffuse slowly and its speed of diffusion is endogenous.
- Once these mechanisms are incorporated, the relative price of capital and the stock market move in opposite directions, as in the data.
- Stock market leads output and moves one order of magnitude more.