Disussion of Aggregate Technology Shocks, Market Returns, and Market Premiums

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Summary

- Positive relationship between R&D Investment and Patents and future returns on the market portfolio.
- Amount of predictability is quite high (16-18% annual R^2s).
- R&D Investment and Patents proxy for technology shocks.
- Results appear consistent with a standard RBC model.
- **Central Intuition:**
  a) Positive technology shock raises the marginal product of capital and therefore future returns to investment.
  b) Stock Returns $\Leftrightarrow$ Investment Returns.

Literature

- Empirical Asset Pricing:
- At the firm level, several authors find positive relationship between R&D investment, measures of TFP or returns on "intangibles" and future excess returns.
  - High R&D-intensive firms earn higher average stock returns than low R&D-intensive firms.

    Chan, Lakonishok and Sougiannis 2001, Li 2006
  - Intangible information predicts future expected returns.

    Daniel and Titman 2006, Vassalou and Apedjinou 2004
- Empirical RBC literature?

Model

Is the evidence consistent with the model?

- Focus on the case where utility is additively separable.
- Model implies that $R_{I,t+1} = R_{m,t+1} = F_K(n, K, A, \varepsilon)$.
  - technology(A) increases F_K, so leads to higher $E_t R_{m,t+1}$

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- But log consumption growth is homoscedastic...

$$\begin{aligned} \frac{C_{t+1}}{C_t} &= \frac{F_{t+1}}{F_t} \\ &= (stuff) \times \exp(a_3(\pi\xi_t + e_{t+1}))\frac{\varepsilon_{t+1}}{\varepsilon_t} \\ var_t(\Delta \ln C_{t+1}) &= a_3^2 var_t(e_{t+1}) + var_t(\Delta \ln \varepsilon_{t+1}) \end{aligned}$$

Risk-free rate vs market premium

	Calibrated Data		**Historical Data**	
Variables	Mean	Standard deviation	Mean	Standard deviation
Technological growth, γ_t	0.005	0.004	0.005	0.001
Output growth, $ln(F_t/F_{t-1})$	0.005	0.008	0.005	0.008
Capital growth, $ln(k_t/k_{t-1})$	0.005	0.004	0.007	0.003
Working time, n_t	0.243	0.000	0.289	0.005
Consumption growth, $ln(c_t/c_{t-1})$	0.005	0.009	0.006	0.006
Productivity growth, $ln(F_t/n_t) - ln(F_{t-1}/n_{t-1})$	0.005	0.008	0.006	0.007
Risk-free asset return, $R_t^f - 1$	0.013	0.004	0.006	0.006
Stock return, $R_t^s - 1$	0.015	0.004	0.022	0.083
$Corr(ln(F_t/F_{t-1}), \xi_t)$	0.883		0.029	
$Corr(R_{t+1}^s, \xi_t)$	0.050		0.231	
$Corr(R_{t+1}^s - R_{t+1}^f, \xi_t)$	0.006		0.239	

- Model: *risk-free rate* increases with technology.
- Data: *risk premium* increases with technology.

Model

- **Bottom Line:** In general equilibrium with homothetic preferences, changes in expected excess returns *must* be due to changes in **risk** or the **price of risk**.
  - If risk stays constant but marginal product of capital increases, firms will want to borrow in order to invest. Since the bond is in zero net supply, the risk free rate will have to increase. So expected stock returns will increase *because* the risk-free rate increases.
- Does either measure of technology shocks predict changes in risk?

Do the technology series predict changes in risk?

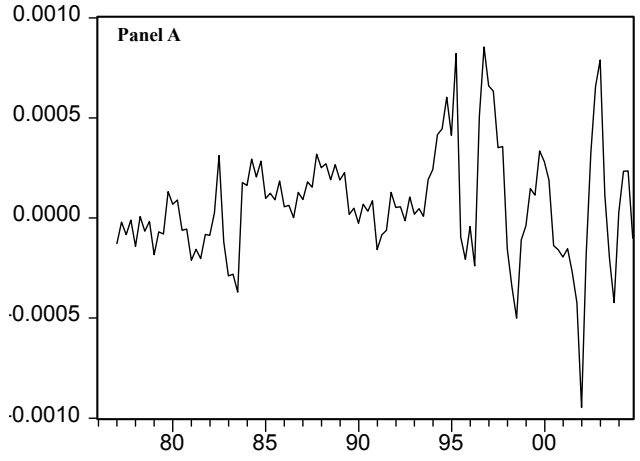
- Do they predict volatility of output, consumption or stock returns?

Variable	$\xi_{pat,t-1}$	$\xi_{rd,t-1}$	$\sigma^2_{M,t-1}$	R^2	Sample
$\sigma^2_{M,t}$	-0.000		0.353	14%	1978-2004
	(-0.85)		(4.41)		
		0.000	0.554	30%	1991-2004
		(0.05)	(4.71)		
Variable	$\xi_{pat,t-1}$	$\xi_{rd,t-1}$	ARCH	GARCH	Sample
var(Δc)	0.000		0.459	-0.344	1978-2004
	(0.03)		(2.55)	(-2.96)	
		0.000	0.387	-0.096	1991-2004
		(0.17)	(1.27)	(-0.19)	
var(Δy)	0.000		0.204	0.761	1978-2004
	(0.03)		(2.45)	(11.77)	
		0.000	0.381	0.653	1991-2004
		(0.43)	(1.97)	(8.67)	

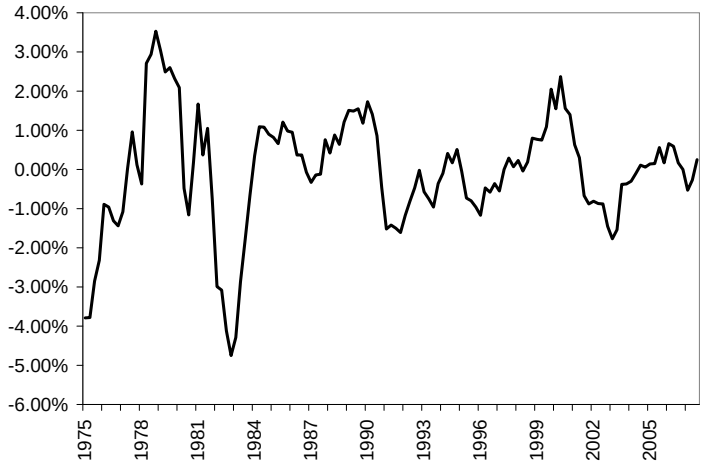
- It is possible they predict changes in the price of risk...

Are they technology shocks?

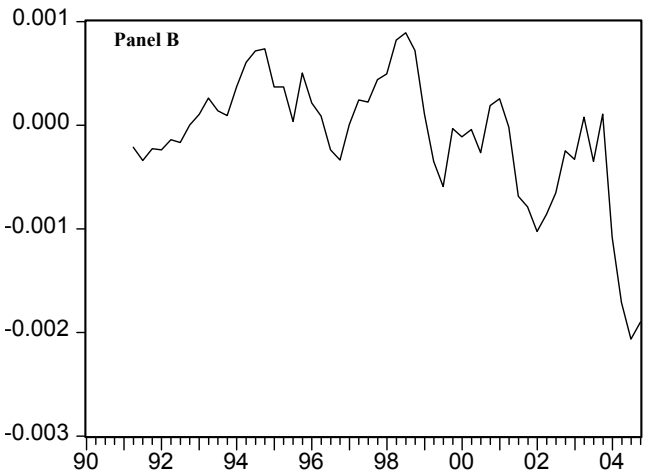
Patent shocks



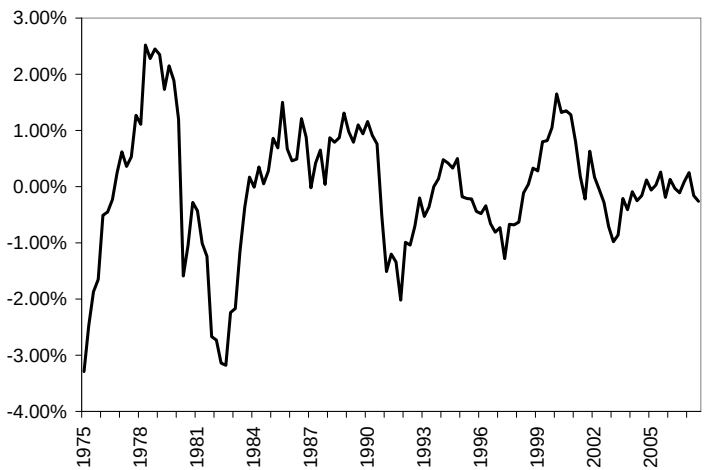
HP filtered log GDP



R&D shocks



HP filtered log C



- The correlation between R&D and Patent shocks is 7%.

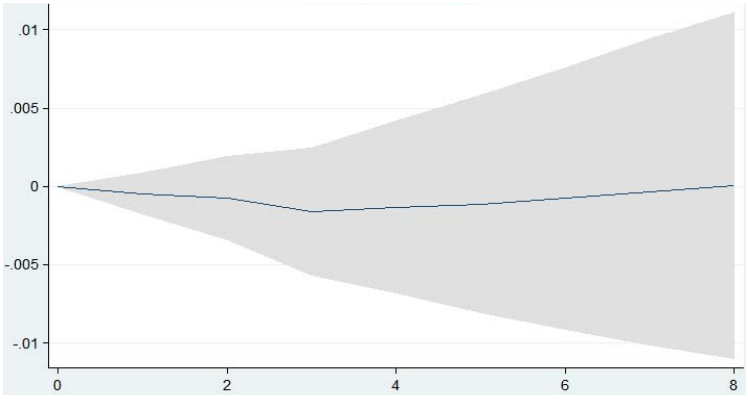
Alternative Explanations

1. R&D could represent investment in“Intangible” or “Knowledge” Capital which might be different/riskier than physical capital.
2. Patents may capture growth options or blueprints that can be converted into projects in the future.
   - Growth options are riskier than existing assets, so maybe premia increase in the amount of growth options.
3. Perhaps firms choose to do R&D in recessions, when profitability of existing projects is low and expected returns are high.
4. Maybe patents lead to new technologies that make the old ones obsolete, output and consumption falls.
   - Lower consumption + DRRA $\rightarrow$ higher expected returns.

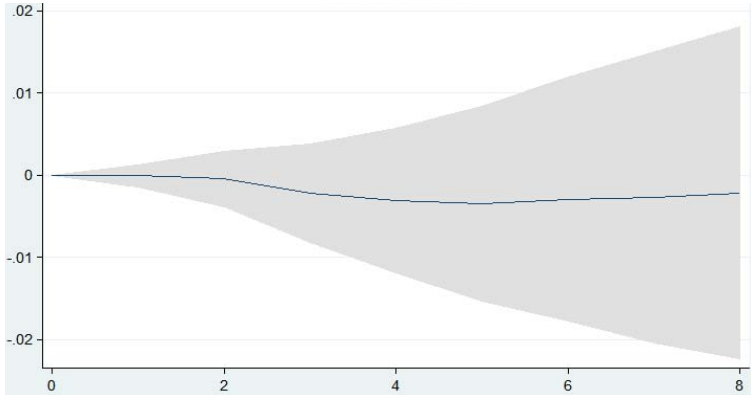
Are they technology shocks?

- Does the technology series predict future output, hours worked or consumption?

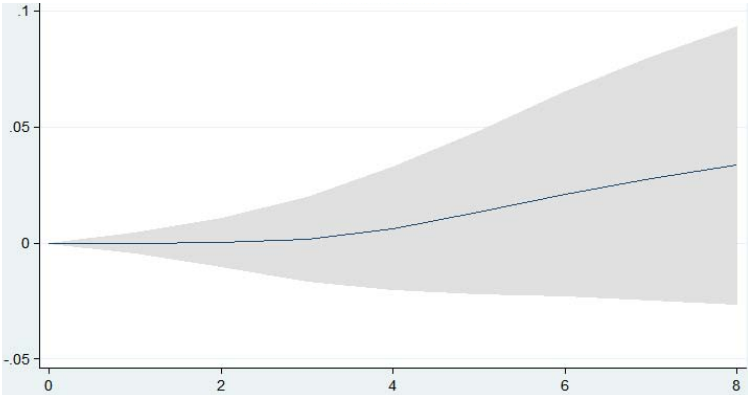
log Y (hpf)



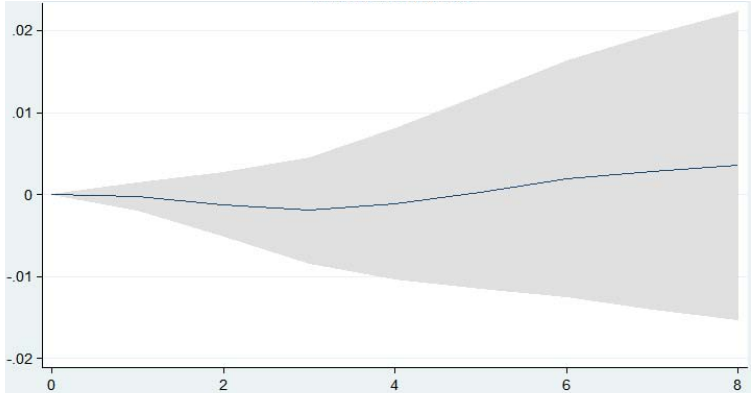
log H (hpf)



log I (hpf)



log C (hpf)



Non-Technology/Behavioral explanations?

- Maybe investors can't evaluate investment in R&D properly.
- Alternatively, investors don't know when patents are filed or R&D takes place and find out much later.
- R&D Investment predicts returns up to 3 years ahead, patent growth up to 1 yr.
- Special Sample? Results for R&D in 1991-2004 period. Hardly representative.
- Results for patents hold in 1977-2004, although less significant (up to 1 yr).

Summary

- Interesting empirical fact, consistent with existing evidence on R&D and intangibles at the firm level.
- The mechanism however is not clear. Changes in risk premia must be fundamentally due to changes in risk or aversion to risk, and model does not capture that.
  - In fact model implies that risk premia are pro-cyclical.
- Additional evidence that these series are technology shocks are needed.
- An exploration of alternative explanations might be useful.