Investment Networks, Sectoral Comovement, and the Changing U.S. Business Cycle

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Discussion: Lilia Maliar

Worum geht es in diesem Papier?

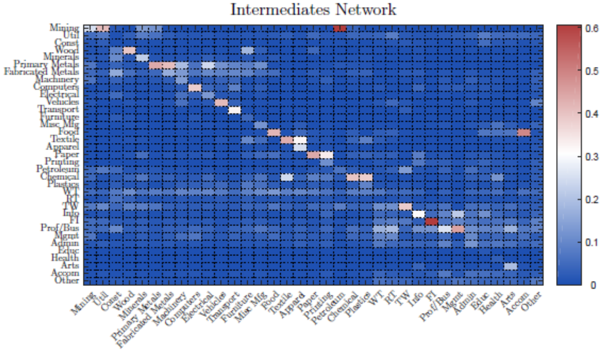
- By paper, I mean a composite of a previous version of the paper (henceforth, LW, 2019) and slides presented today.
- *Motivation:* explain RBC patterns in two subperiods
  – before 1984
  – after 1984.
- Nonstationary aggregate patterns of interest:

	before 1984	**after 1984**	**change**
labor productivity	highly procyclical	roughly acyclical	$\downarrow$ by 60%
output	more volatile	less volatile	$\downarrow$ by 40%

$\Longrightarrow$ Relative volatility of labor to that of output $\uparrow$ by 34%.

- Also, volatility of agg. investment relative to output increased in post-1984 period.
- *Idea:* to relate these nonstationary RBC patterns to sectoral comovements.

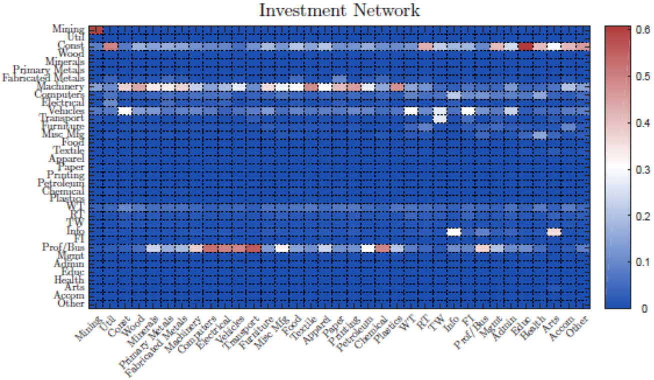
- Model with linkages in intermediate goods and investment goods across manufacturing sectors (35 in total).
- The industries receive/provide the intermediate goods and services from/to other sectors:



BEA I-O databases 1947-2017

Worum geht es in diesem Papier? (cont.)

- Production of investment goods is concentrated in a small number of sectors – "investment hubs", IH.
- LW (2019): an IH comprises at least 10% of the investment goods in a different sector.



BEA capital flows (1997) plus fixed assets 1947-2017

Worum geht es in diesem Papier? (cont.)

Propagation of "investment hub shocks"

- Let NH = non-hub sector
- Productivity in NH ↑
  - Value added of NH ↑
  - Employment of NH ↑
  - Demand for investment in NH ↑
  - This increase in investment demand must be met by IHs
  - IHs ↑ their demands for other sectors' intermediate goods
  - Employment ↑ in all sectors
- Thus, employment is driven by "investment-hub shocks".

Worum geht es in diesem Papier? (cont.)

- Within-sector patterns are stationary:

	before 1984	**after 1984**	**change**
labor productivity	procyclical	procyclical	0%
output	highly volatile	less volatile	$\downarrow$ by 16%

$\Longrightarrow$ Relative volatility of labor to that of output did not change.

- Driving forces at the sector level:

	before 1984	**after 1984**
value added	aggregate TFP shocks	sector-level TFP shocks
employment	aggregate TFP shocks	investment-hub shocks

Comment 1: Why a multisector model?

- LW (2019) motivate their work by the basic RBC facts:
  – labor productivity is highly procyclical in pre-1984 and roughly acyclical in post-1984 years.
- Using the multisector RBC model, LW (2019) show that sectoral heterogeneity matters for agg. dynamics.
- But the consumer heterogeneity also matters for aggregate dynamics and can lead to acyclical productivity.
- *For example, Maliar and Maliar (2001, JEDC) consider optimal growth model with consumers heterogeneous in wealth and productivities and obtain:*

	$\gamma = 1$, $\sigma = 1$	$\gamma = 1$, $\sigma = \frac{1}{5}$	$\gamma = \frac{3}{5}$, $\sigma = 1$	$\gamma = \frac{3}{5}$, $\sigma = \frac{1}{3}$	$\gamma = \frac{3}{5}$, $\sigma = \frac{1}{5}$	$\gamma = \frac{3}{5}$, $\sigma = \frac{3}{20}$
σ_n	0.70	1.16	0.97	1.65	1.85	2.01
$corr\left(\frac{y}{n}, y\right)$	0.98	0.99	0.97	0.59	0.17	-0,17

Comment 2: Why are there just two subperiods?

1. LW (2019) consider just **2 subperiods**: before 1984 and after 1984.
   – What is special about 1984?
   – How are two solutions (for two subperiods) are put together?
2. All parameters other than shocks are **constant** over time:
   – E.g., intermediate and investment I-O networks are averages across 1947-2017.
   – Covariance matrix Σ_τ in the process for the sector-specific TFP,

$$\log A_{jt+1} = \rho_j \log A_{jt} + \varepsilon_{jt+1}, \qquad \varepsilon_{jt+1} \sim \mathcal{N}\left(0, \Sigma_\tau\right),$$

   differs in two subperiods, $\Sigma_\tau = \left(\Sigma_{pre-1984}, \Sigma_{post-1984}\right)$.

- Thus, LW (2019) document non-stationary patterns but use a stationary model to account for them.

Comment 2: Why are there just two subperiods? (cont.)

- It would be natural that these periods (pre-1984 and post-1984) were not fixed.
- Instead, there is a process for each parameter that changes over time.
- There is evidence in the literature on time-changes in
  – depreciation rate δ_j;
  – labor share $1 - \alpha_j$;
  – volatility of sector-specific shocks.
- Other parameters that they can make time-dependent in their model:
  – value-added shares θ_j;
  – intermediate I-O network Γ_{ij};
  – investment I-O network Λ_{ij};
  – consumption shares ξ_j.
- Now they are computed as averages over 1947-2017 (the benchmark model) or as averages in 2 subperiods.

Extended function path (EFP) methodology for solving nonstationary models

- I want to show the methodology that
  – characterizes the solutions that change over time;
  – solves non-linearly.
- My presentation is based on the paper "Tractable Framework for Analyzing a Class of Nonstationary Markov Models" (joint with S. Maliar, J. Taylor and I. Tsener), NBER 21155.
- Publicly provided code: "*EFP_MMTT_2015.zip" - Extended Function Path (EFP) method for time-dependent models.*

Example of a nonstationary growth model

We now introduce nonstationary Markov environment into dynamic general equilibrium modeling paradigm:

$$\max_{\{c_t, k_{t+1}\}_{t=0}^{\infty}} E_0 \left[\sum_{t=0}^{\infty} \beta^t u_t \left(c_t \right) \right]$$

$$\text{s.t. } c_t + k_{t+1} = (1-\delta) k_t + f_t \left(k_t, z_t \right),$$

$$z_{t+1} = \rho_t z_t + \sigma_t \varepsilon_{t+1}, \qquad \varepsilon_{t+1} \sim \mathcal{N}(0,1),$$

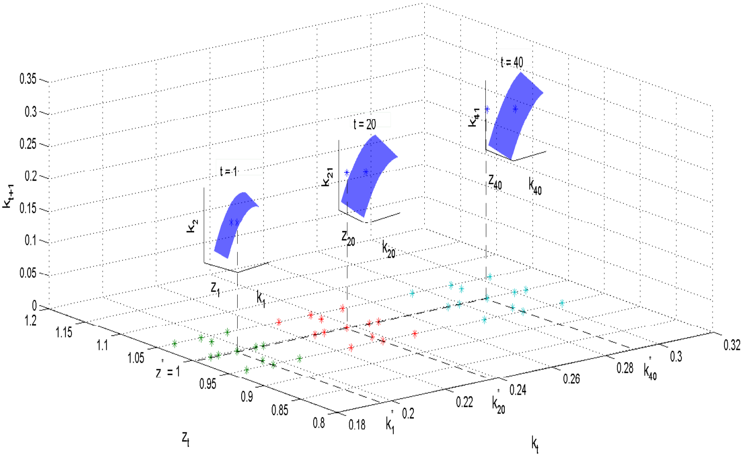
– sequence of u_t, f_t and φ_t for $t \geq 0$ is known to the agent in period $t = 0$; ε_{t+1} is i.i.d;
– $\rho_t \in (-1, 1)$ and $\sigma_t \in (0, \infty)$ are given at $t = 0$.

Introducing extended function path (EFP) framework

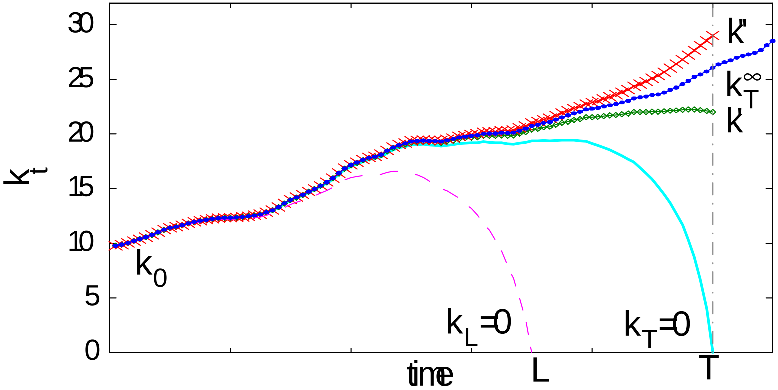
Extended function path (EFP) framework includes two steps.

- **Solving a T-period stationary economy:** Assume that in a very remote period T, the economy becomes stationary, i.e., the utility and production functions and the laws of motions for exogenous shocks are time invariant, i.e., $u_t = u$, $f_t = f$, $\rho_t = \rho$ and $\sigma_t = \sigma$ for all $t \geq T$:
  $\Rightarrow$ we *can solve for equilibrium using conventional methods for stationary models.*
- **Constructing a function path:** Using the T-period solution as terminal condition, iterate backward on optimality conditions to construct a sequence (path) of time-dependent value and decision functions $(V_0(\cdot), V_1(\cdot), ...)$ and/or $(K_0(\cdot), K_1(\cdot), ...)$.
  $\Rightarrow$ *this is like solving OLG models.*

Example of function path constructed by EFP



When you are young, you behave as if you will live forever...



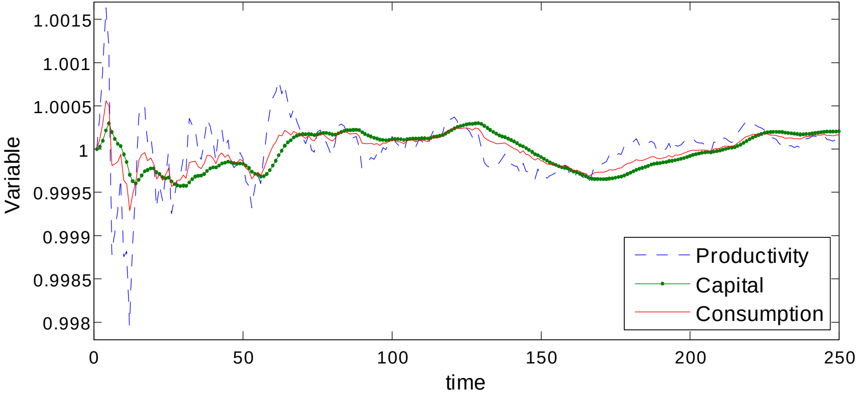
Modeling diminishing volatility

- There is evidence that the volatility has a well pronounced time trend, Mc Connel and Pérez-Quiros (2000), Blanchard and Simon (2001), Stock and Watson (2003):
- This kind of evidence cannot be reconciled in a model in which stochastic volatility follows a standard AR(1) process with stationary transitions.
- We modify the standard neoclassical stochastic growth model to include time-varying diminishing volatility of the productivity shock:

$$\ln z_t = \rho \ln z_{t-1} + \sigma_t \varepsilon_t, \qquad \sigma_t = \frac{B}{t^{\rho_\sigma}}, \quad \varepsilon_t \sim \mathcal{N}(0,1),$$

  – B = a scaling parameter;
  – ρ_σ = a parameter that governs the volatility of z_t.
- We solve for a sequence of the optimal decision functions $(K_0(\cdot), K_1(\cdot), \ldots)$.

Modeling diminishing volatility (cont.)



Other examples of nonstationary applications

In the paper, we show many other examples of nonstationary applications including:

- unbalanced growth models;
- deterministic trends in the data (population growth, climate changes, etc.);
- different kinds of technological progress that augment productivity of different factors, e.g., directed technical change;
- an entry into and exit from a monetary union (Brexit);
- nonrecurrent policy regime switches;
- deterministic seasonals;
- changes in the consumer's tastes and habits;
- estimation of parameters in nonstatinary model.

- Potentially, EFP can be also used to solve a fully nonstationary model of LW (2019).

Conclusion

- **An excellent paper:**
  – documented many new interesting empirical regularities on changing business cycles;
  – their theory is consistent with their empirical regularities;
  – explain economic mechanisms behind the changes in patterns;
  – provide supportive evidence of mechanisms.
- The model describes well the average behavior of comovement across all sectors.
  – the model's R^2 is 52%!
- Future work might address the arbitrariness of the cut-off period (i.e., 1984) and analyze a fully nonstationary RBC model.