# The Dynamic Consequences of Technology and Discount Factor Shocks in Medium-Scale RANK vs TANK Models

Andreas Koundouros

Presentation for the Research Module Macroeconomics at the University of Bonn

24th January 2023

# Roadmap

1. Introduction and Related Literature
2. The Models
3. The Shocks
4. Results
5. Conclusion

# Introduction

Go to related literature

- aim: contrast a representative-agent to a two-agent framework
  $\Rightarrow$ RANK vs TANK
- two household types in TANK: standard agents and **hand-to-mouth** agents
- analyse how dynamics after aggregate shocks are altered
- two shocks: to technology and to the **discount factor**

# Key Results

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2. underlying heterogeneity of individual-level responses is interesting feature of TANK

3. two parameters are key in shaping the quantitative differences between RANK and TANK

# The Models

- building on Gust et al. (2012) and Boehl (2022) with price indexation
- crucial difference RANK vs TANK: household sector

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- building on Gust et al. (2012) and Boehl (2022) with price indexation
- crucial difference RANK vs TANK: household sector
- RANK: representative, consumption-smoothing agent with access to investment, bonds, profits, etc. resulting in standard labour supply and Euler equation:

$$w_t = \chi n_t^{\eta}(c_t - hc_{t-1}) \tag{2.1}$$

$$1 = \beta_{t+1}\frac{R_t}{\pi_{t+1}}\frac{(c_t - hc_{t-1})}{(c_{t+1} - hc_t)} \tag{2.2}$$

plus standard budget constraint Go to budget constraint

# The TANK Model (I)

- unit-mass population, of which a share $(1 - \lambda)$ are standard, consumption-smoothing households

- these **unconstrained** agents behave just as RANK agents
  $\Rightarrow$ identical equations (2.1), (2.2), budget constraint

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- unit-mass population, of which a share $(1 - \lambda)$ are standard, consumption-smoothing households
- these **unconstrained** agents behave just as RANK agents
  $\Rightarrow$ identical equations (2.1), (2.2), budget constraint
- a share $\lambda$ is **hand-to-mouth** and consume only current-period labour income with no access to consumption-smoothing tools

# The TANK Model (II)

– hand-to-mouth households are characterised by labour supply and budget constraint:

$$w_t = \chi(n_t^H)^\eta(c_t^H - hc_{t-1}^H) \tag{2.3}$$

$$c_t^H = w_t n_t^H \tag{2.4}$$

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- hand-to-mouth cannot save or dissave in the face of shocks

- consumption of hand-to-mouth tied exclusively to labour market
  $\Rightarrow$ labour market of great importance for TANK dynamics

# The TANK Model (III)

– final step for TANK model is economy-wide aggregation:

$$c_t = (1-\lambda)c_t^U + \lambda c_t^H \tag{2.5}$$

$$n_t = (1-\lambda)n_t^U + \lambda n_t^H, \tag{2.6}$$

where:

$c_t$, $n_t$: aggregate consumption and employment

$c_t^U$, $n_t^U$: unconstrained agents' consumption and employment

$c_t^H$, $n_t^H$: hand-to-mouth agents' consumption and employment

# The Discount Factor Shock

– the discount factor evolves according to:

$$\beta_t = \beta_{ss} \left( \frac{\beta_{t-1}}{\beta_{ss}} \right)^{\rho_\beta} \exp(\varepsilon_{\beta,t}) \tag{3.1}$$

where $\varepsilon_{\beta,t} = 0.02$ in $t = 1$, $\beta_{ss} = 0.98$, $\rho_\beta = 0.8$

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- what can one expect to happen?
  - contraction in today's consumption, output, wages, inflation, interest rates (both models)
  - in TANK, unconstrained agents should act analogously to RANK-agents; hand-to-mouth will most likely be hit somewhat stronger as they cannot smooth consumption

# Results

– calibration: mostly used the given values, but following Kaplan et al. (2018) and Debortoli and Galí (2018): $\lambda = 0.3$ and $\eta = 1$

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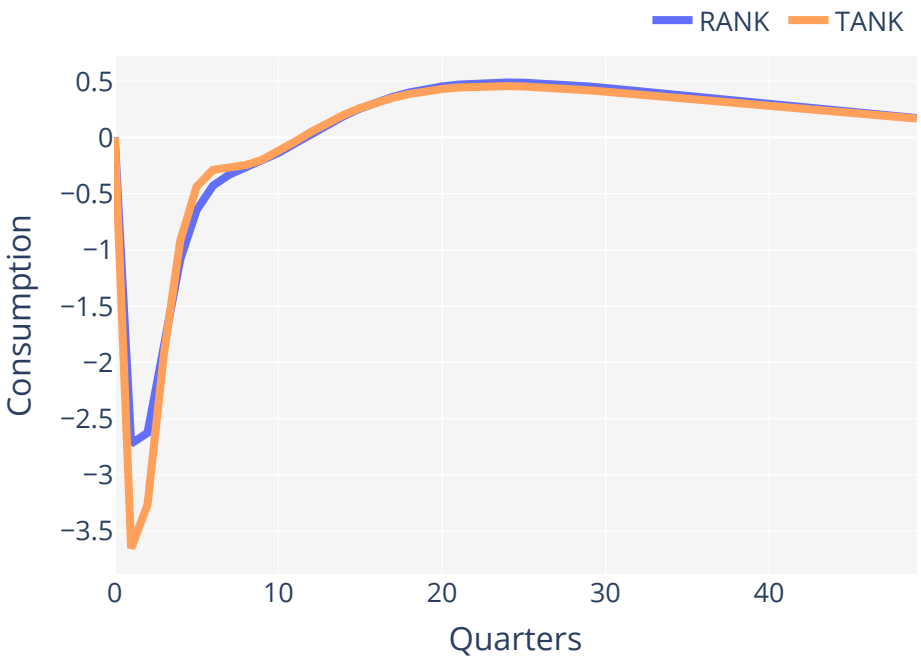
- roadmap for the results:
  1. responses to a discount factor shock

     ▸ Go to technology shock

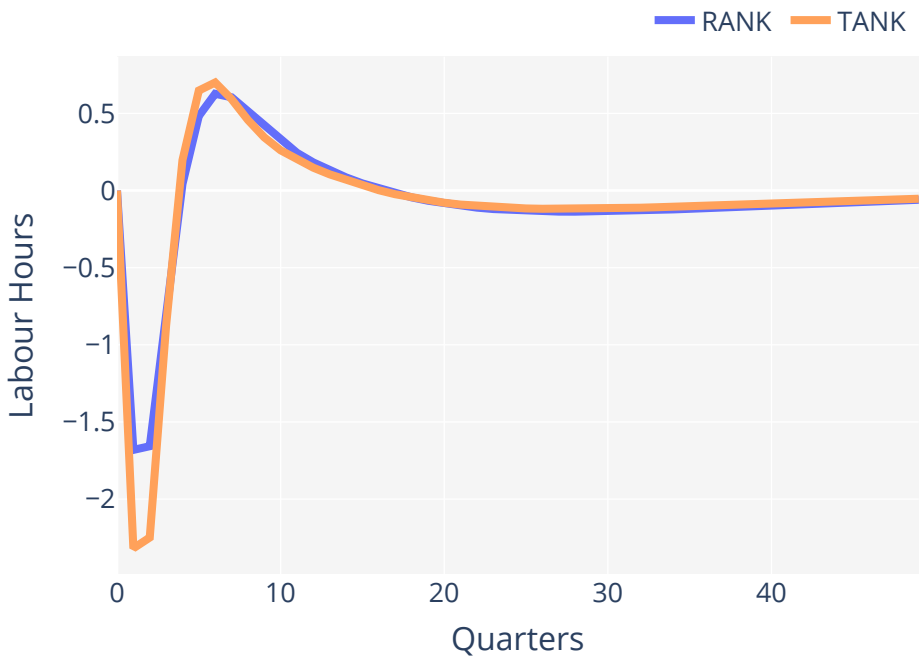
  2. influence of $\lambda$ and $\eta$ on quantitative differences

# Figure: Aggregate Responses to a Discount Factor Shock

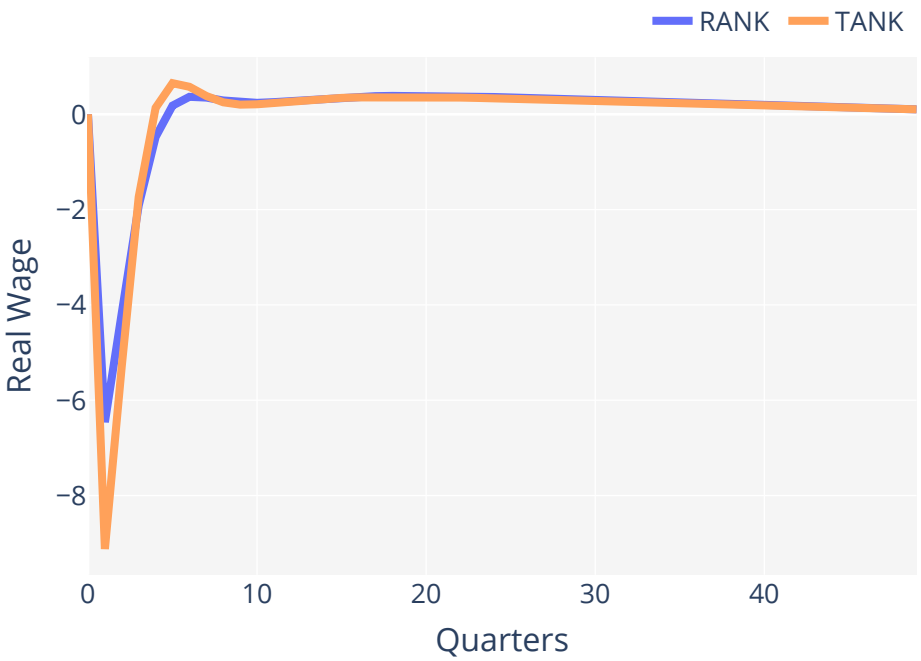
## (a) Consumption



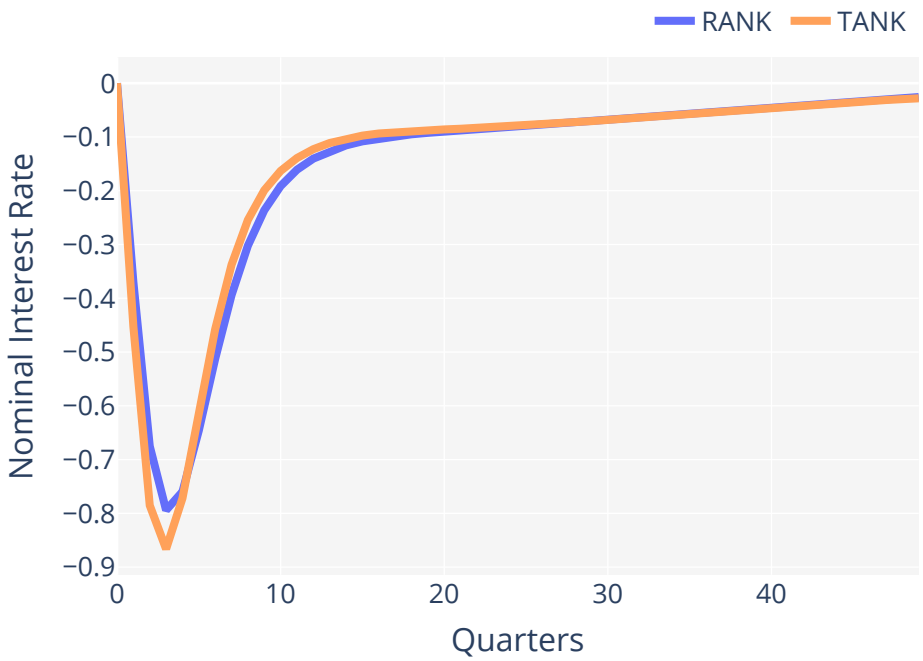

## (b) Labour Hours



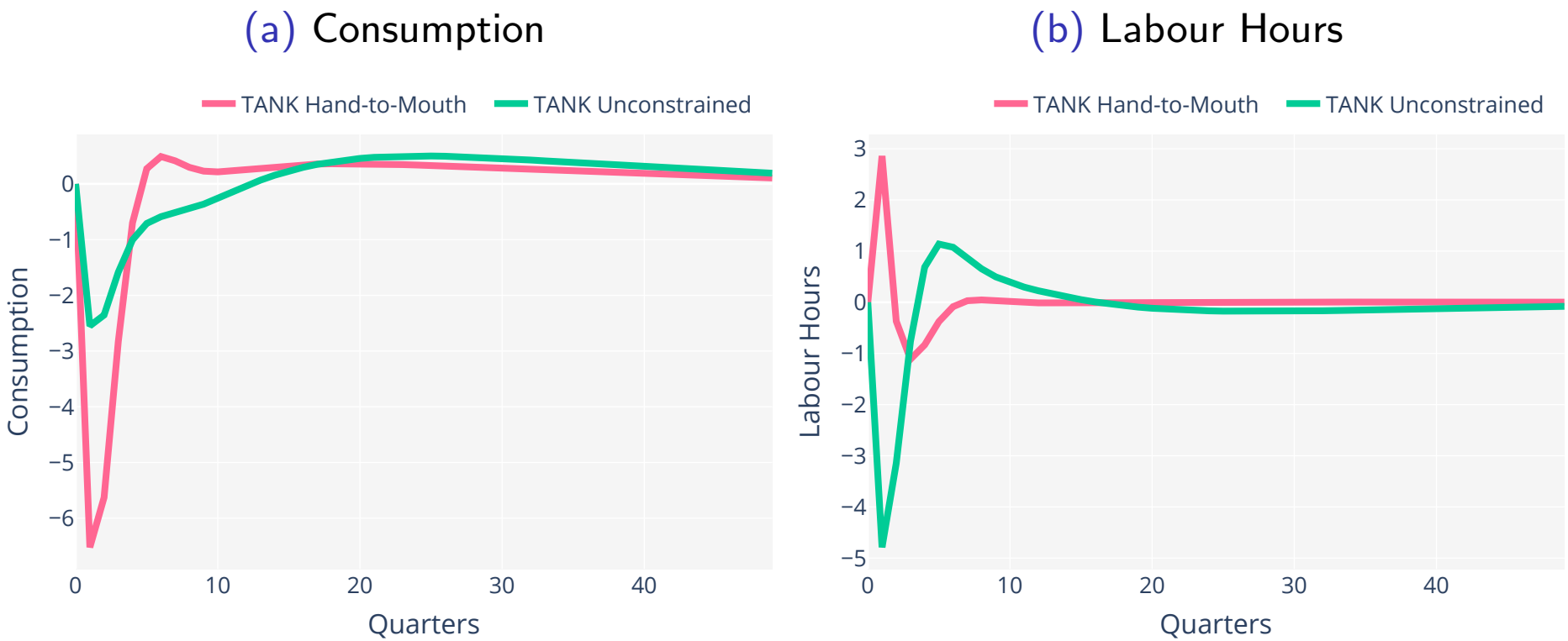
(c) Wage




(d) Nominal Interest Rate



# Figure: Individual-Level Responses to a Discount Factor Shock (TANK)

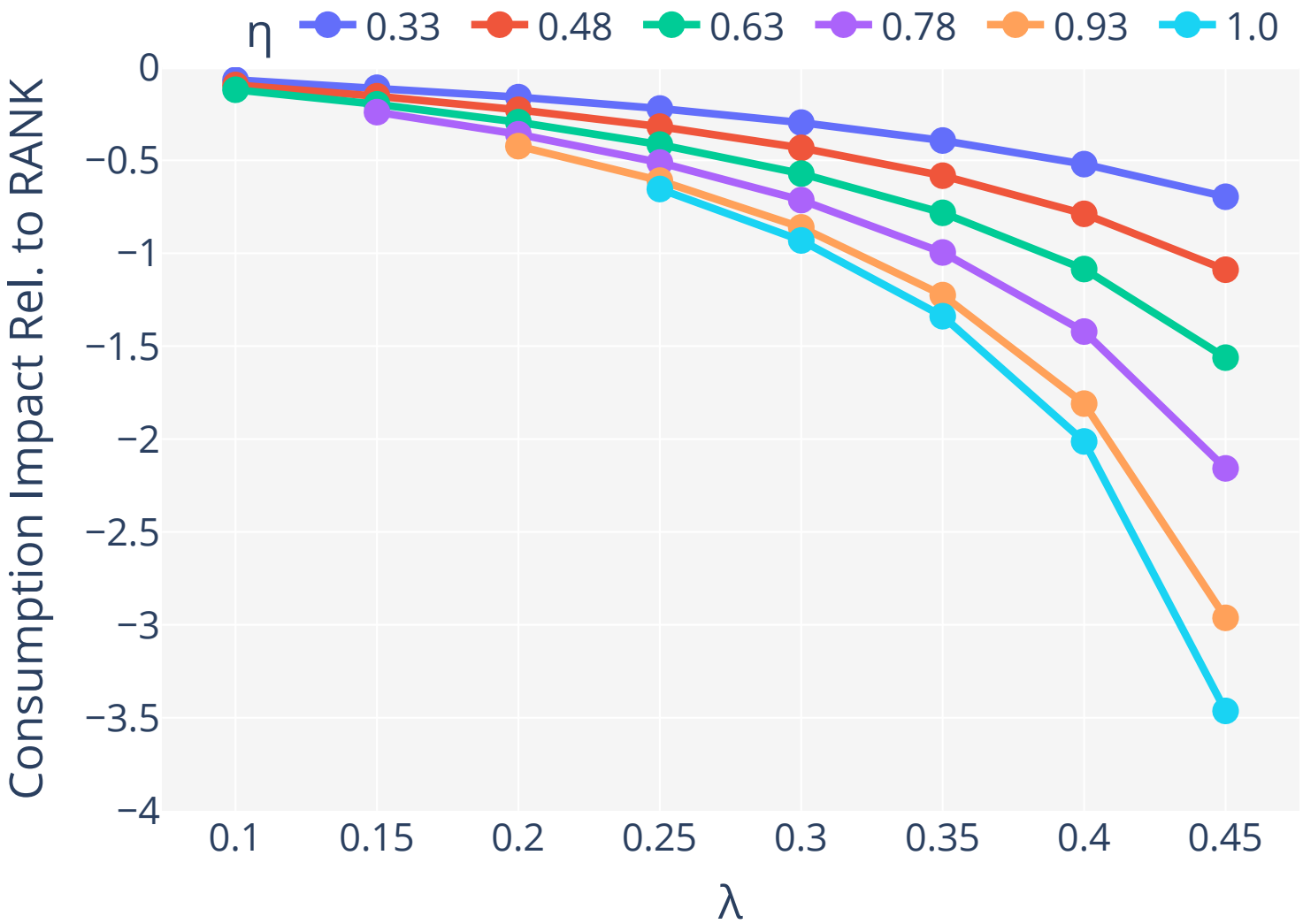


# Sensitivity Analysis (I)

- check how the quantitative **relative differences** between RANK and TANK depend on choices of $\lambda$ and $\eta$
- focus on aggregate consumption effects **on impact** after discount factor shock

▸ Go to technology shock

# Figure: Aggregate Consumption Response on Impact to a Discount Factor Shock as a Function of $\lambda$ and $\eta$



# Sensitivity Analysis (II)

- higher $\lambda \Rightarrow$ stronger impact in TANK relative to RANK for given $\eta$
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- higher $\lambda \Rightarrow$ stronger impact in TANK relative to RANK for given $\eta$
- higher $\eta \Rightarrow$ stronger impact in TANK relative to RANK for given $\lambda$
- **interaction** of high $\eta$ and $\lambda$ leads to most pronounced difference
- intuition: together, high $\lambda$ and high $\eta$, imply:
  - labour market developments matter substantially (many hand-to-mouth)
  - **and** wage changes do not translate as much into changes in hours worked (low elasticity of labour to wages)

# Conclusion

– key findings of simple RANK vs TANK comparison:

1. responses usually coincide qualitatively
2. for baseline calibration, quantitative differences not too large
3. magnitude of differences depends on $\lambda$ and $\eta$

# Conclusion

- key findings of simple RANK vs TANK comparison:
  1. responses usually coincide qualitatively
  2. for baseline calibration, quantitative differences not too large
  3. magnitude of differences depends on $\lambda$ and $\eta$
- myriad of possible extensions:
  - include HANK and compare it to RANK & TANK
  - consider fiscal policy and redistribution
  - estimation of key parameters, especially $\lambda$ and $\eta$

**Thank you very much for your attention!**

Any questions?

# References


Boehl, G. (2022). *Econpizza: Solving Nonlinear Heterogeneous Agents Models Using Machine Learning Techniques*. https://econpizza.readthedocs.io/en/latest/index.html

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Galí, J., López-Salido, J. D., & Vallés, J. (2007). Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association*, *5*(1), 227–270.

Gust, C., Herbst, E., López-Salido, D., & Smith, M. E. (2012). The Empirical Implications of the Interest-Rate Lower Bound. https://www.federalreserve.gov/econresdata/feds/2012/files/201283r1pap.pdf

Kaplan, G., Moll, B., & Violante, G. L. (2018). Monetary Policy According to HANK. *American Economic Review*, *108*(3), 697–743.

# Appendix A: Related Literature ▸ Back

- one of the first papers to do TANK similar to the present model is by Galí et al. (2007)
- seminal paper by Kaplan et al. (2018) on monetary policy transmission in fully-fledged HANK models: direct vs indirect effects of a real interest rate shock
- Debortoli and Galí (2018): prototypical HANK model features three key aspects of heterogeneity; the most important one is the gap in consumption between unconstrained and constrained agents; TANK can replicate this and its aggregate responses are thus close to HANK

# Appendix B: Household Budget Constraint

Back

– this is the budget budget constraint of RANK households as well as of unconstrained TANK agents:[1]

$$dd_t + c_t + \tau_t + \frac{\Phi}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 i_t = w_t n_t + \frac{R_{t-1}}{\pi_t} dd_{t-1} + \ldots \quad (6.1)$$

$$\ldots\left(1 - mc_t - \frac{\psi}{2}\left(\frac{\pi_t}{\tilde{\pi}_{t-1}} - 1\right)^2\right) y_t + \ldots$$

$$\ldots\left(q_t\left(1 - \frac{\Phi}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - 1\right) i_t + bprof_t\right.$$

[1] In the latter case, $c_t^U$ and $n_t^U$ replace $c_t$ and $n_t$, respectively.

# Appendix C: The Technology Shock

Back

– technology adheres to:

$$z_t = z_{ss}\left(\frac{z_{t-1}}{z_{ss}}\right)^{\rho_z}\exp(\varepsilon_{z,t}) \tag{6.2}$$

where $\varepsilon_{z,t} = 0.02$ in $t = 1$, $z_{ss} = 1$, $\rho_z = 0.8$

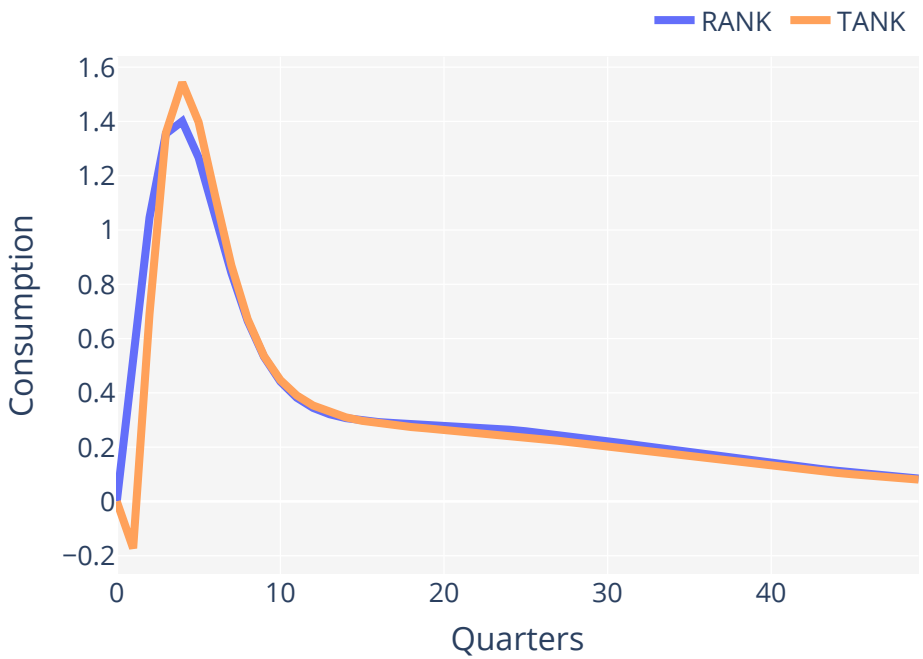
– what can one expect to happen?

  – most likely expansion in production, output, consumption as well as drop in labour hours (well-documented fact in NK literature) and inflation (as output does not rise sufficiently due to price adjustment costs), leading to decrease in nominal interest rate

  – in TANK certainly heterogeneous effects as unconstrained households receive higher firm profits and hand-to-mouth suffer from decrease in wages

# Figure: Aggregate Responses to a Technology Shock

(a) Consumption

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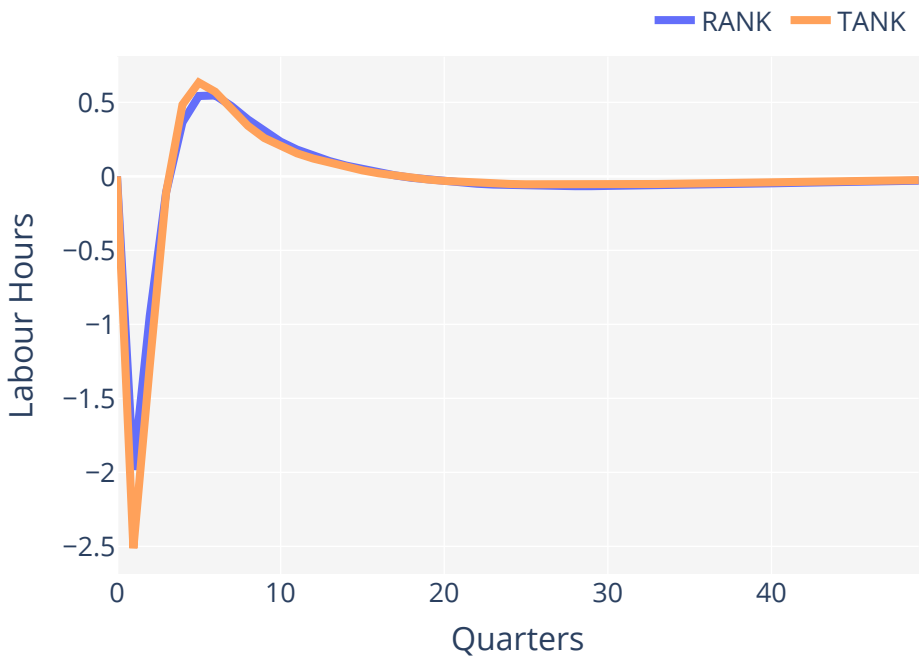

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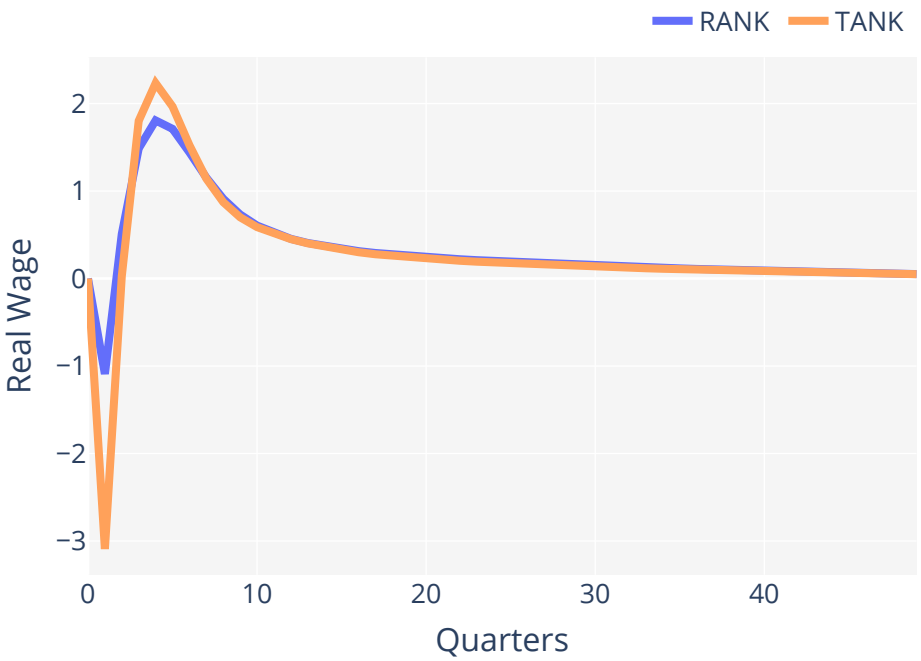


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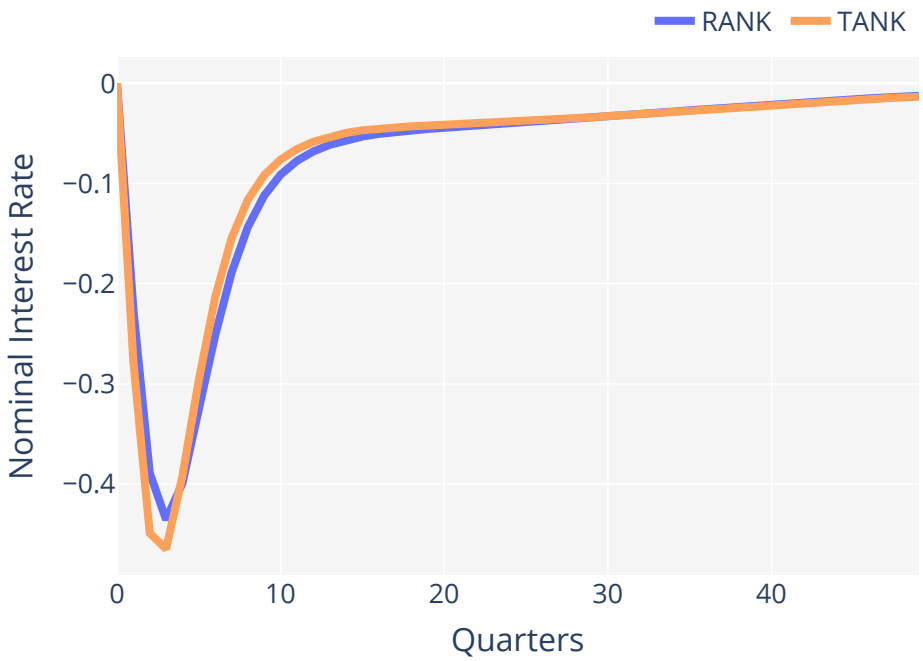

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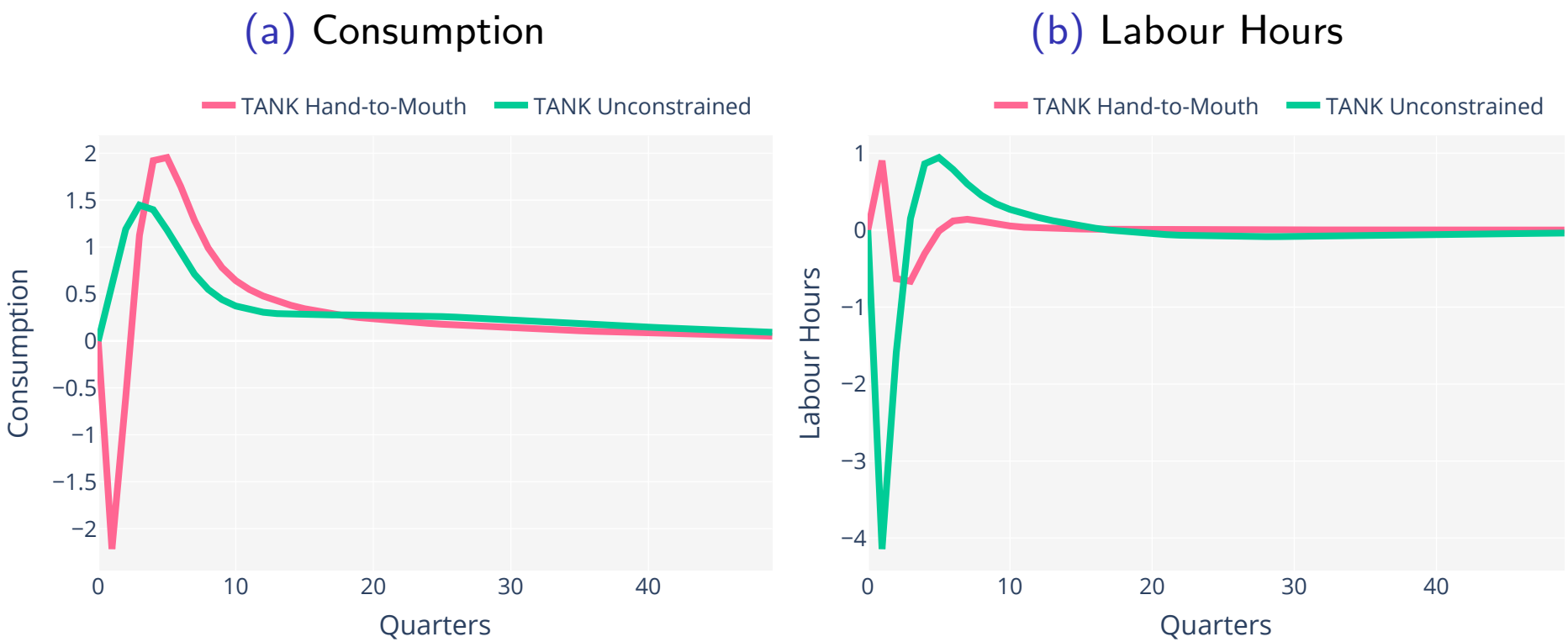

Back

Figure: Aggregate Consumption Response on Impact to a Technology Shock as a Function of $\lambda$ and $\eta$