
Bonus lecture: Pricing models

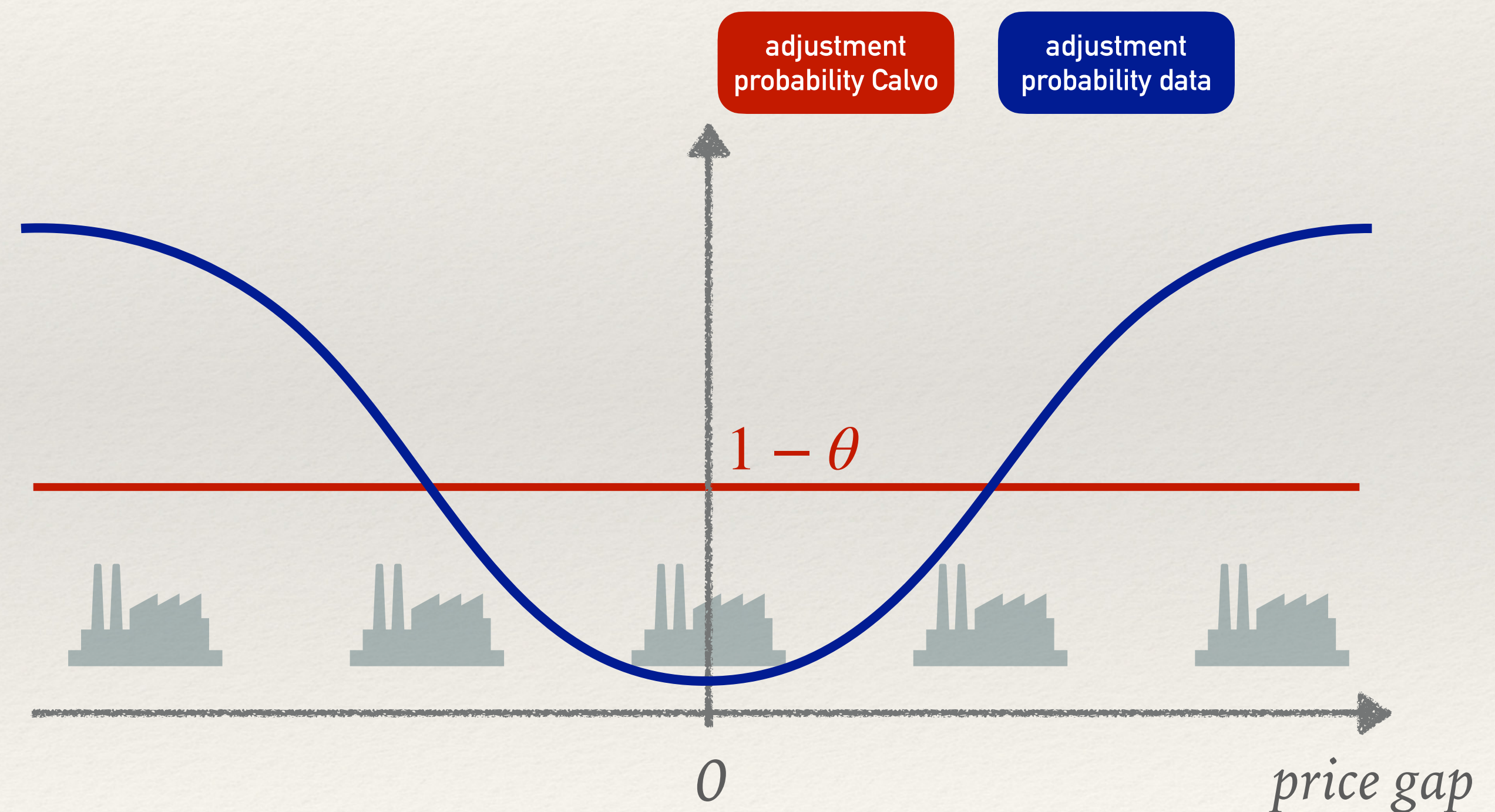
Adrien Auclert

Fiscal and Monetary Policy with Heterogeneous Agents
Bank of Portugal Minicourse
June 2026

The New-Keynesian Phillips Curve

$$\pi_t = \kappa \widehat{mc}_t + \beta \mathbb{E}_t \pi_{t+1}$$

- ❖ Built on strong assumptions:
 - ❖ Rotemberg or **Calvo pricing**
 - ❖ Not in line with **micro data**!
- ❖ Not in line with macro data either!
 - ❖ no inertia, too forward looking
 - ❖ slope κ too high!



Can we do better?

- ❖ Lots of research on **menu cost models**
 - [Bils-Klenow, Nakamura-Steinsson, Gertler-Leahy, Klenow-Kryvtsov, Golosov-Lucas, Midrigan, Alvarez-Lippi, Vavra, Karadi-Schoenle-Wursten,...]
- ❖ firms can always adjust, just need to pay a cost
- ❖ ... but what is the **Phillips curve with menu cost models**?
- ❖ What does “Phillips curve” even mean with menu cost models?

Can we do better?

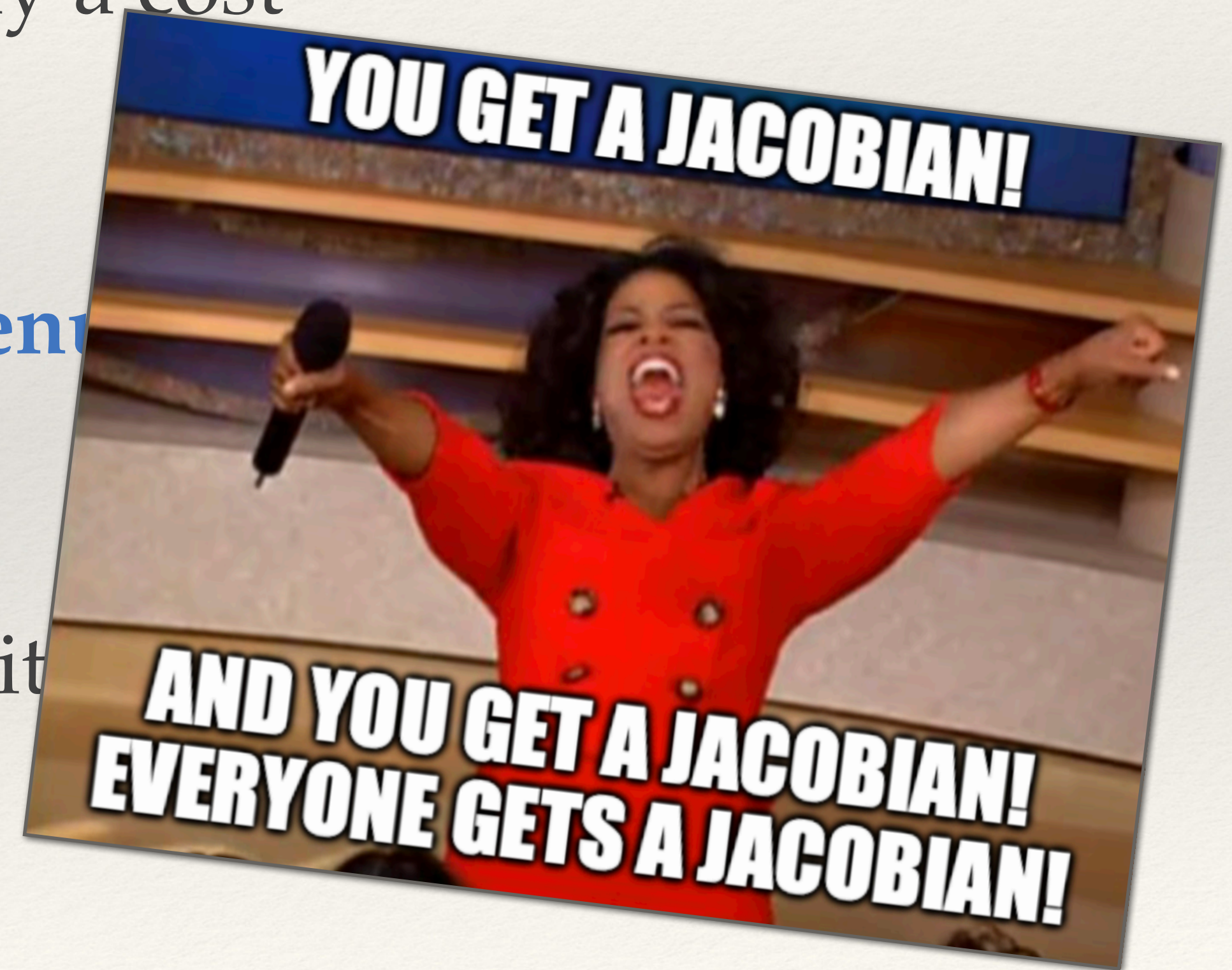
- ❖ Lots of research on **menu cost models**

[Bils-Klenow, Nakamura-Steinsson, Gertler-Leahy,
Klenow-Kryvtsov, Golosov-Lucas, Midrigan,
Alvarez-Lippi, Vavra, Karadi-Schoenle-Wursten,...]

- ❖ firms can always adjust, just need to pay a cost

- ❖ ... but what is the **Phillips curve with menu costs**

- ❖ What does “Phillips curve” even mean with



Warm-Up: What is a “Phillips curve”?

$$\{\widehat{mc}_t\} \longrightarrow \{\pi_t\}$$

This is the heart of the Phillips curve!

$$\{\widehat{MC}_t\} \xrightarrow{\quad} \{\widehat{P}_t\} \iff \{\pi_t\}$$

$$\widehat{MC}_t = \widehat{mc}_t + \widehat{P}_t$$

Two crucial Jacobians

- ❖ **Pass-Through Matrix** (this is what is at the heart of the Phillips curve)

$$\hat{P} = \Psi \cdot \widehat{MC}$$

- ❖ **Generalized Phillips Curve**

$$\hat{\pi} = K \cdot \widehat{mc}$$

- ❖ We can derive **K** from **Ψ** ...

$$K = (I - L)(I - \Psi)^{-1}\Psi$$

Calvo model

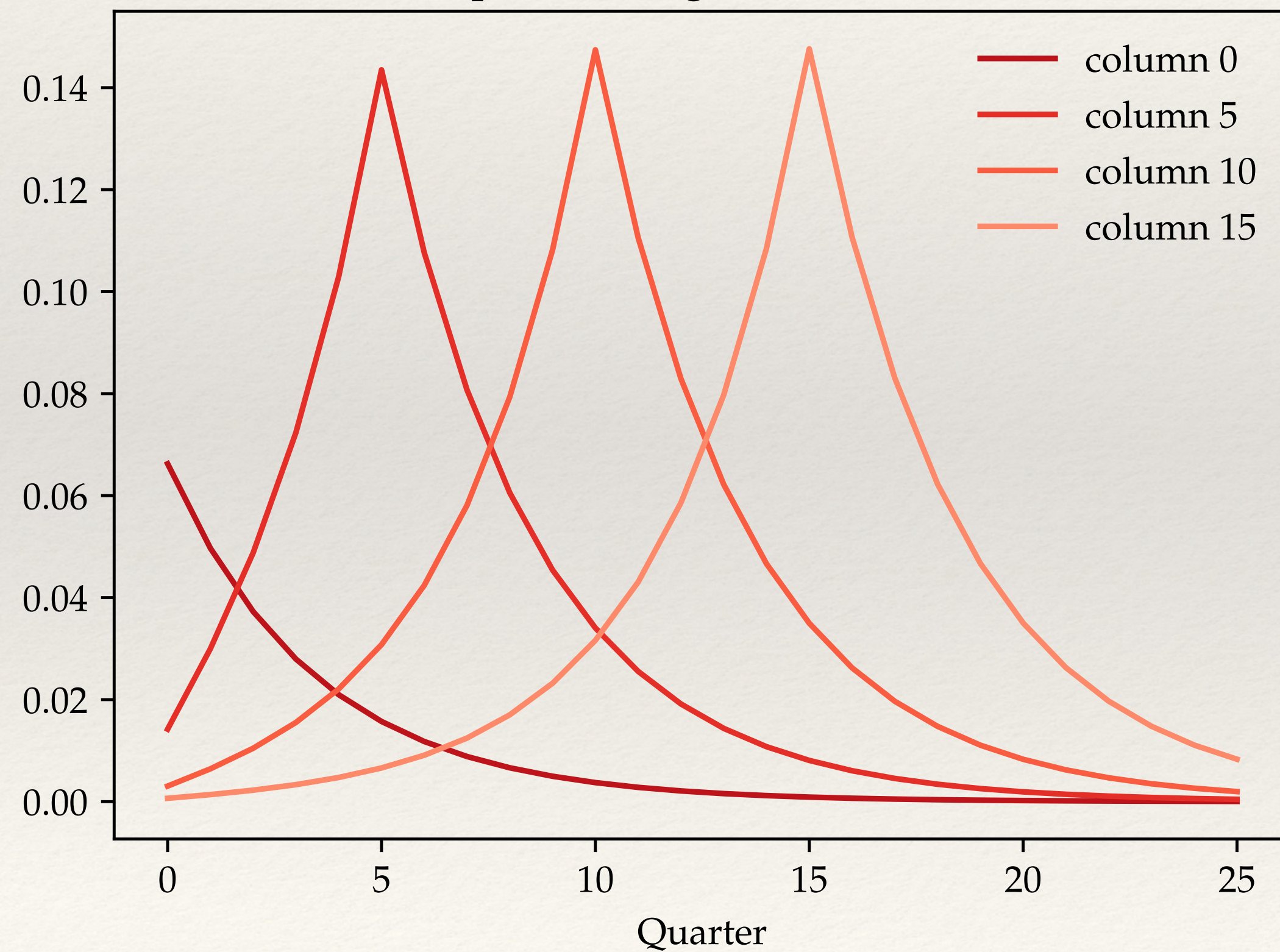
$$\begin{aligned}
 \Psi &\equiv (1 - \theta) \begin{pmatrix} 1 & 0 & 0 & \dots \\ \theta & 1 & 0 & \dots \\ \theta^2 & \theta & 1 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} \cdot (1 - \beta\theta) \begin{pmatrix} 1 & \beta\theta & (\beta\theta)^2 & \dots \\ 0 & 1 & \beta\theta & \dots \\ 0 & 0 & 1 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} \\
 \mathbf{K} &= \begin{pmatrix} \kappa & \beta\kappa & \beta^2\kappa & \dots \\ 0 & \kappa & \beta\kappa & \dots \\ 0 & 0 & \kappa & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} \quad \kappa = \frac{(1 - \theta)(1 - \beta\theta)}{\theta} \quad \Leftrightarrow \quad \pi_t = \kappa \widehat{mc}_t + \beta \mathbb{E}_t \pi_{t+1}
 \end{aligned}$$


Special case of a “time dependent” model with exponential “survival function” θ^t

Calvo model

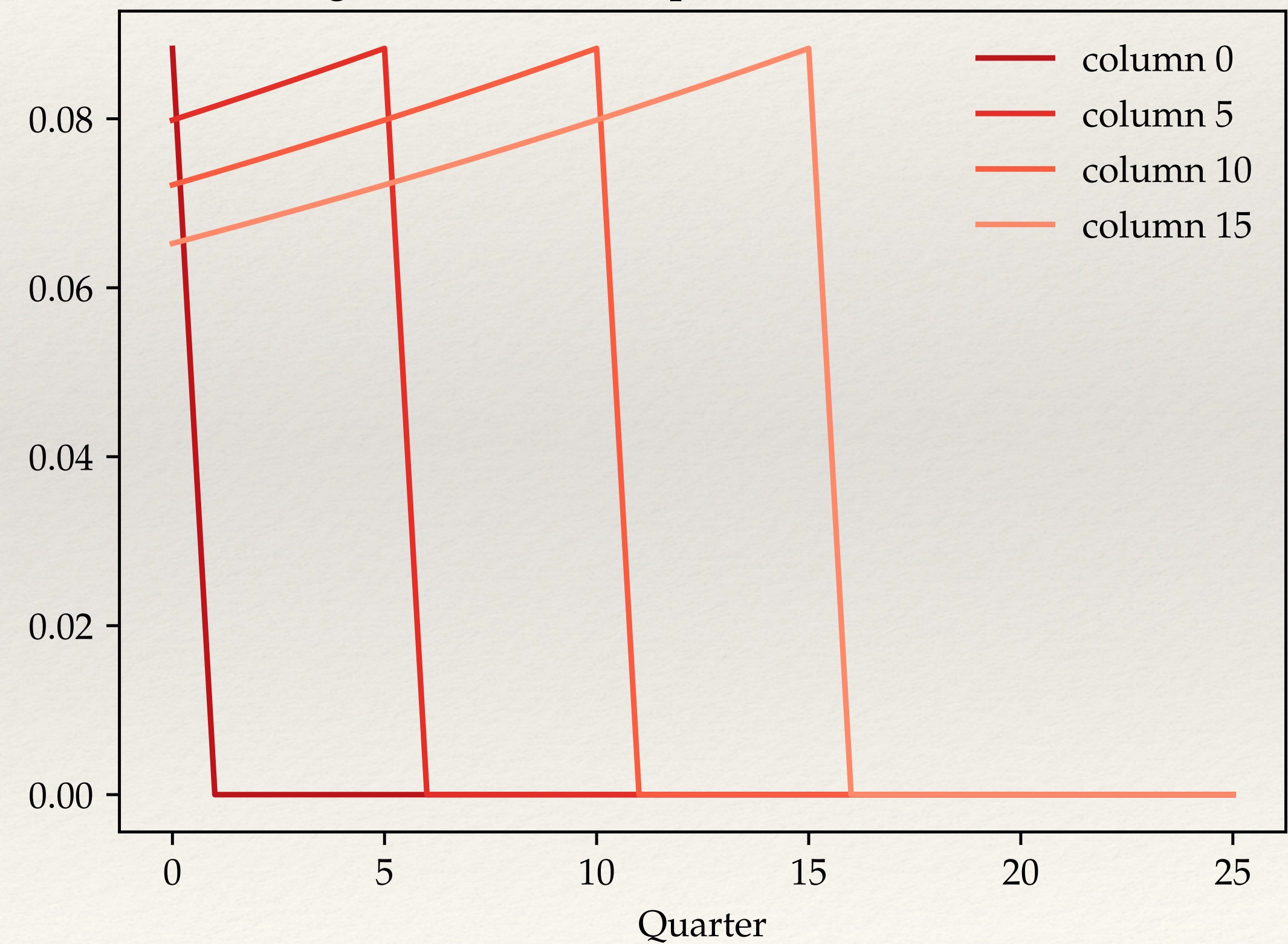
Ψ

Calvo pass-through matrix, $\theta = 0.75$



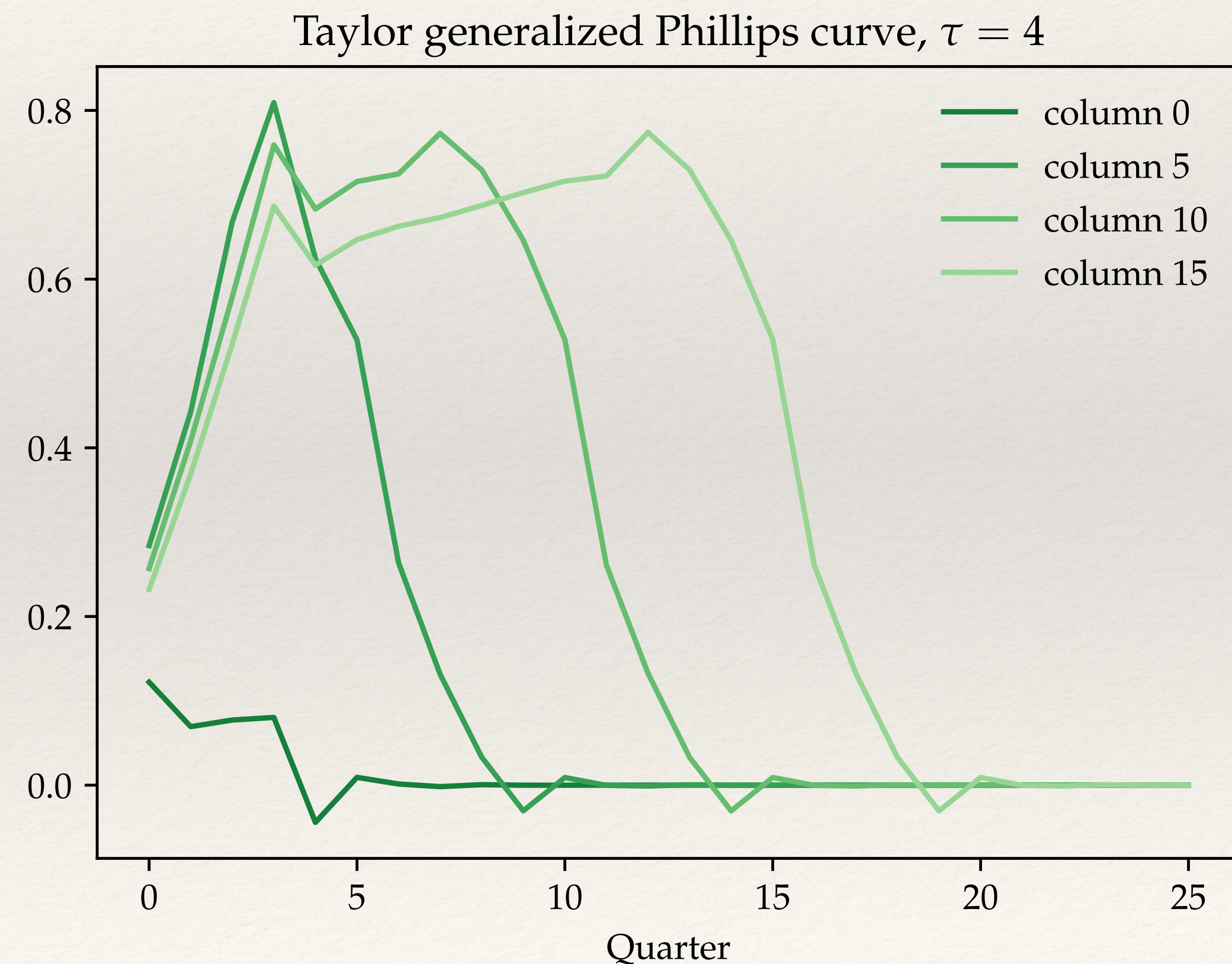
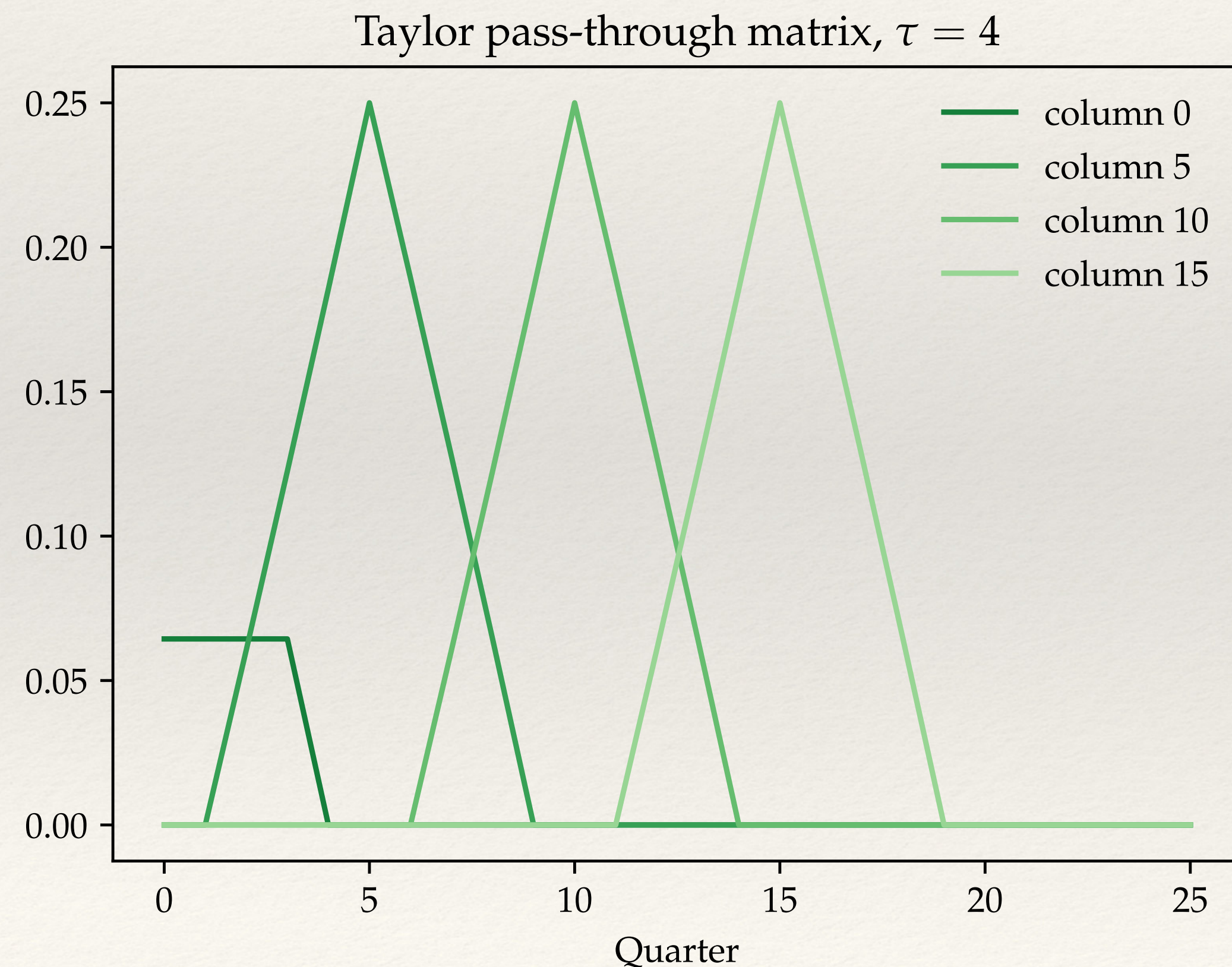
K

Calvo generalized Phillips curve, $\theta = 0.75, \kappa = 0.09$



Another time-dependent model: Taylor

❖ Taylor model: Get to reset every τ periods (e.g. every year). Survival: $1_{\{t \leq \tau\}}$



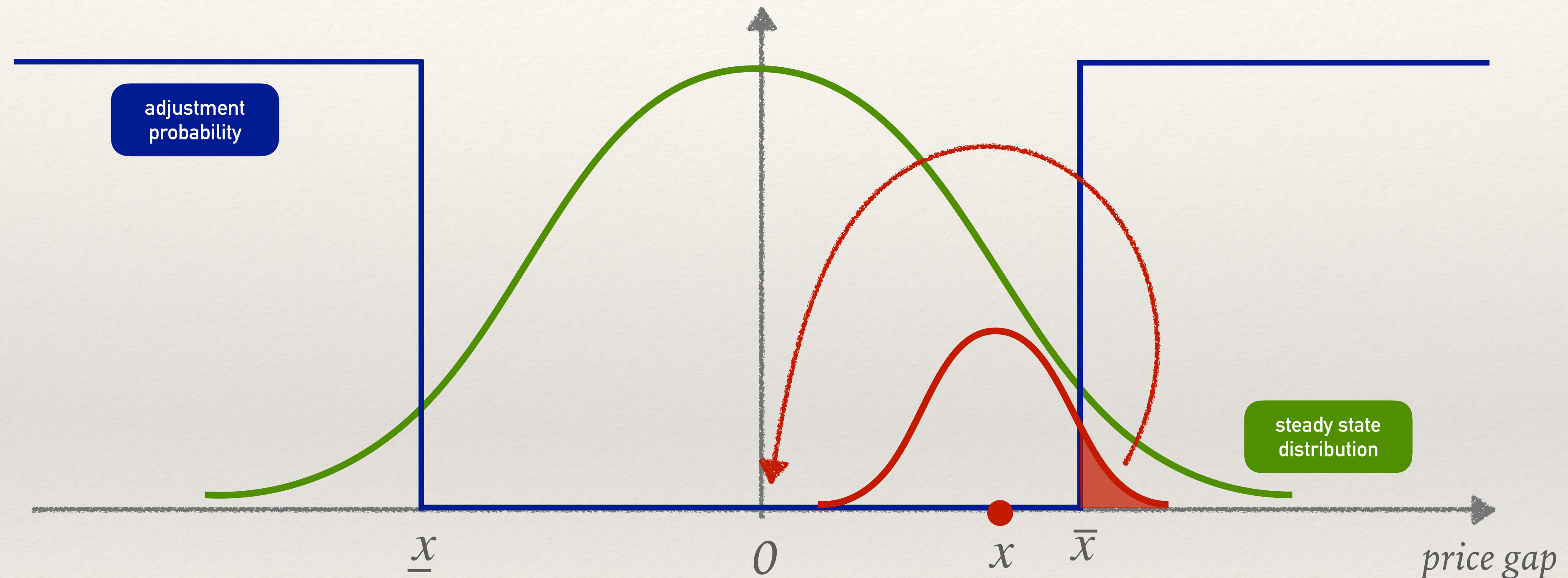
Menu cost model

- ❖ Mass 1 of firms, choosing distance to their optimal price (“**price gap**”) x_{it}
- ❖ Without any shocks, want to set $x_{it} = 0$! With shocks, want $x_{it} = \widehat{MC}_t$
- ❖ But each price reset costs some $\xi > 0$ (“menu cost”)
- ❖ If price is not reset, price gap moves: $x_{it} = x_{it-1} - \epsilon_{it}$

$$\min_{\{x_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2} \left(x_{it} - \widehat{MC}_t \right)^2 + \xi 1_{\{x_{it} \neq x_{it-1} - \epsilon_{it}\}} \right]$$

- ❖ Lots of evidence for this kind of behavior in micro data on price setting!

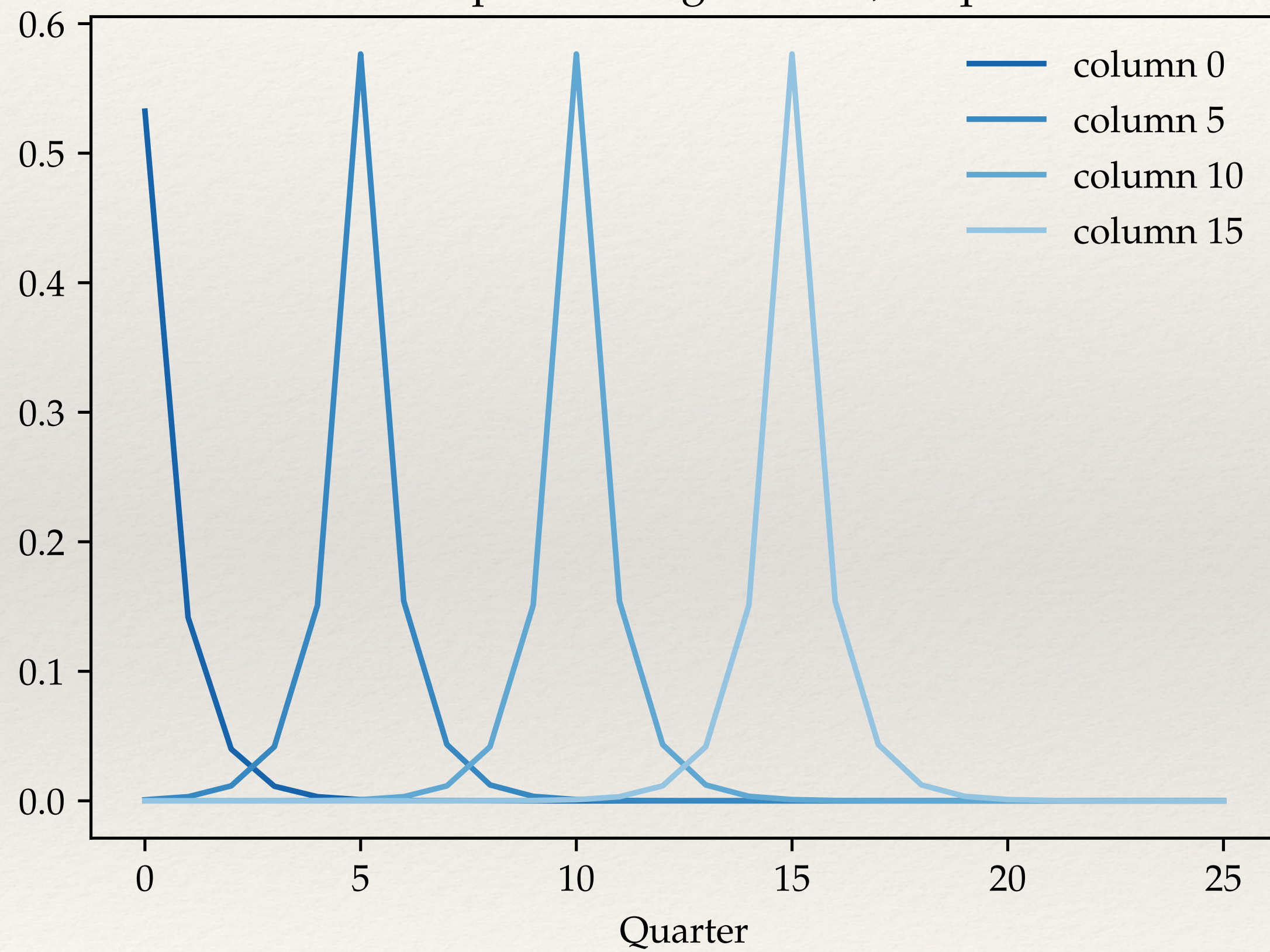
Mechanics of menu cost models



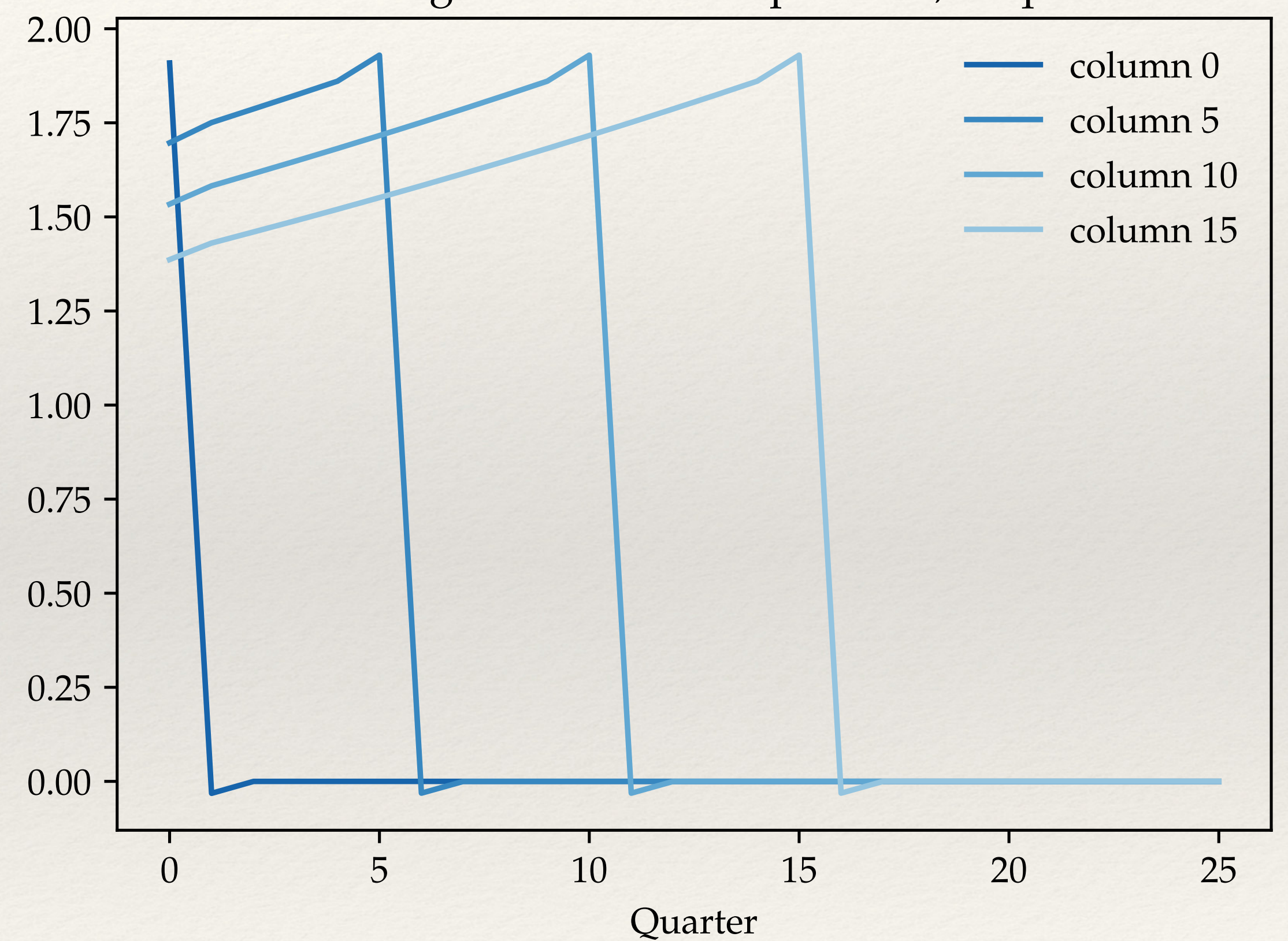
- ❖ Entire distribution of price gaps matters! “State dependent” model
- ❖ Hard to analyze... Main focus on permanent MC shocks, i.e. $\Psi \cdot 1$

What do menu cost Jacobians look like?

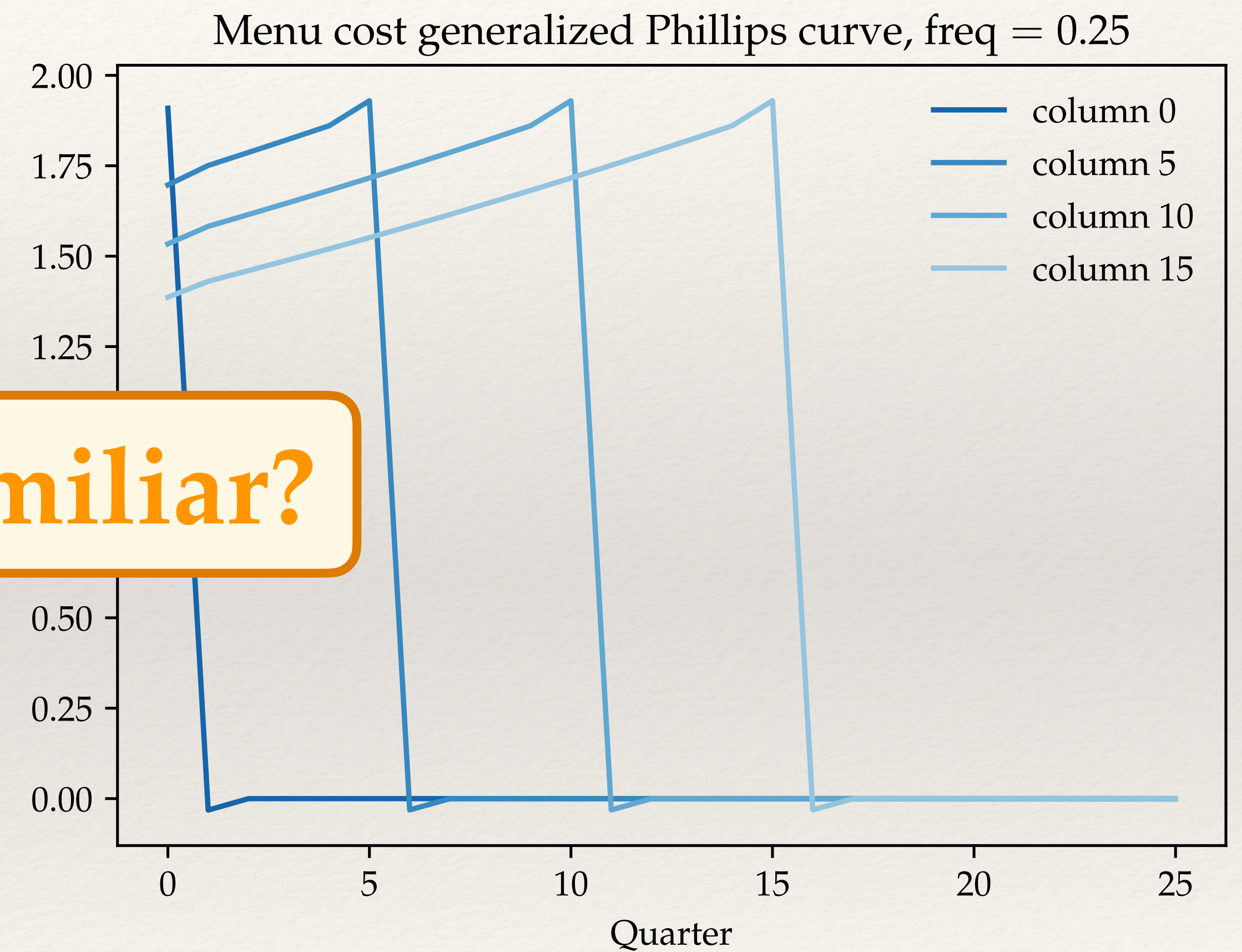
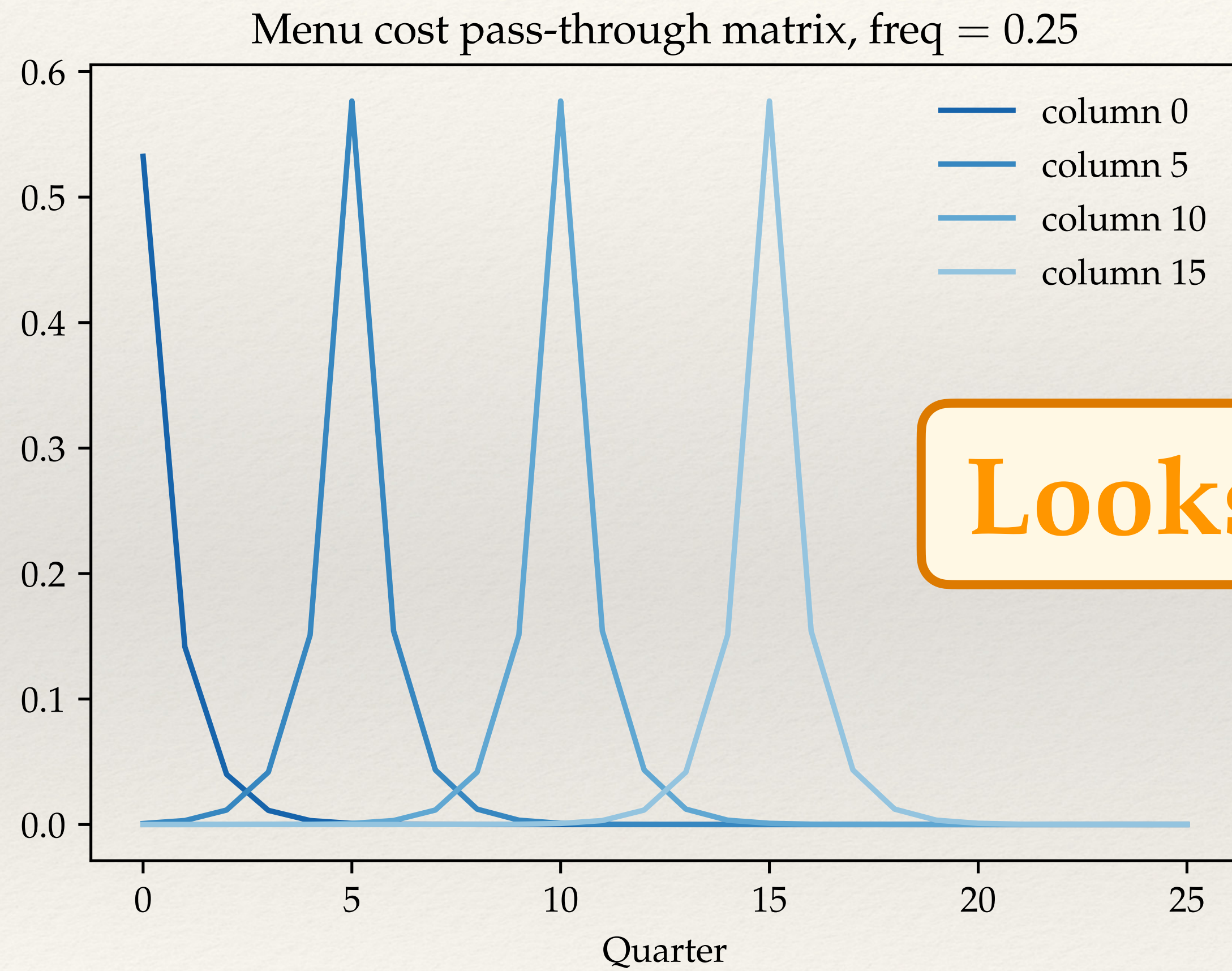
Menu cost pass-through matrix, freq = 0.25



Menu cost generalized Phillips curve, freq = 0.25

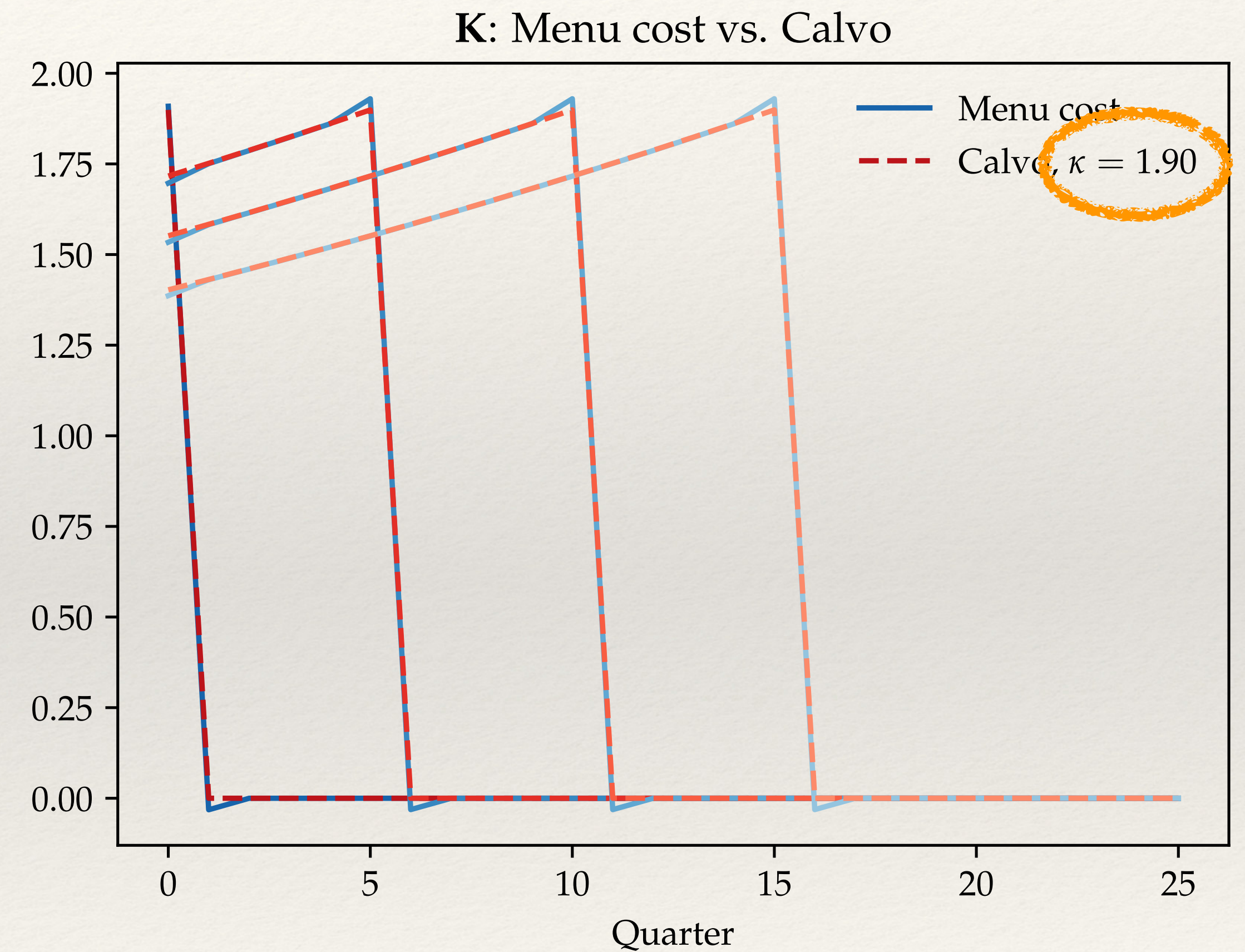
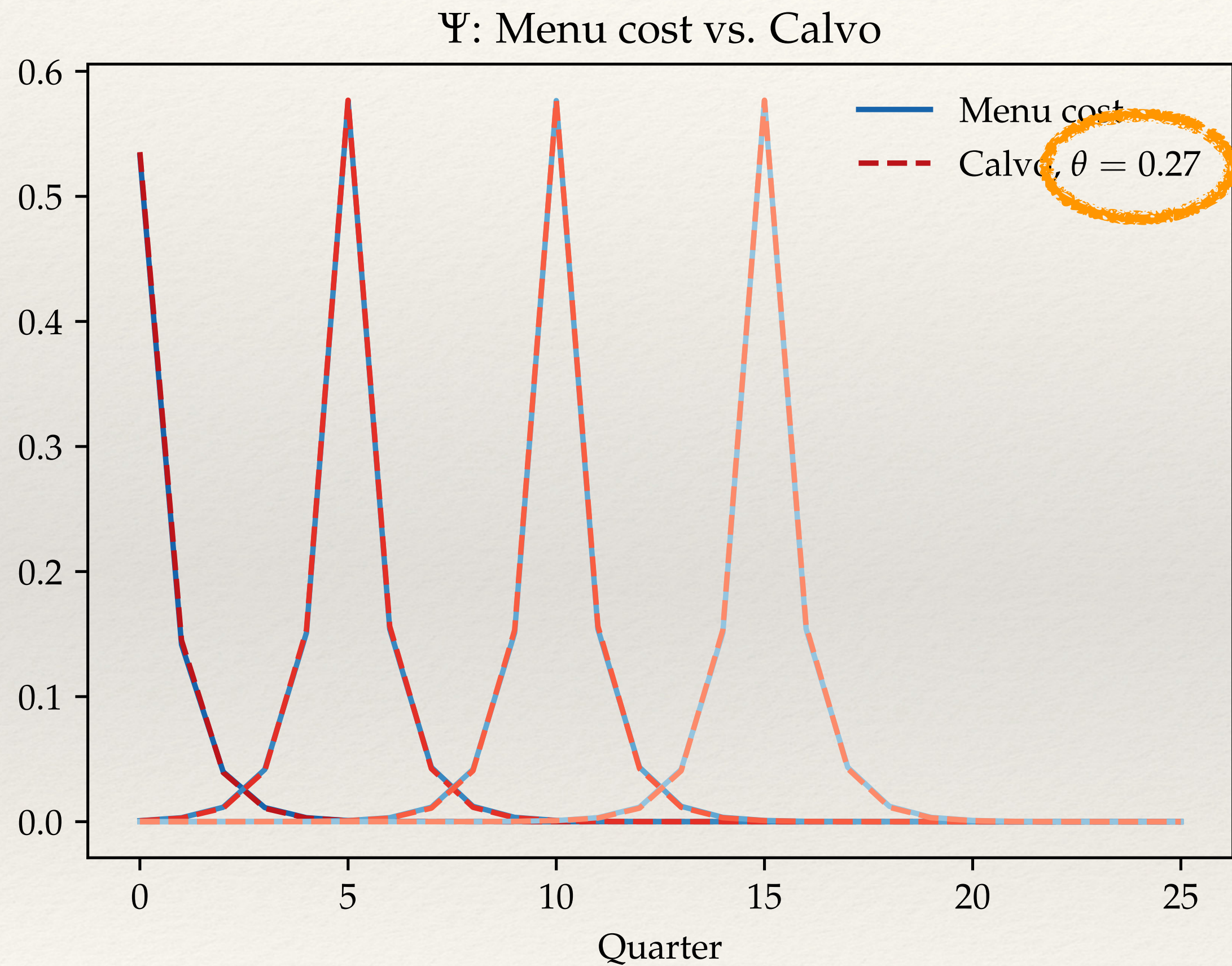


What do menu cost Jacobians look like?



Looks familiar?

What do menu cost Jacobians look like?



Numerical equivalence result

- ❖ **Pass through matrix** and **generalized Phillips curve** of menu cost models are well approximated by a Calvo model with a greater frequency of price resets.
- ❖ Since it holds for Jacobians, it holds for arbitrary menu cost shocks.
- ❖ This holds across various parameterizations of menu cost models
- ❖ To summarize, to first order:

Calvo

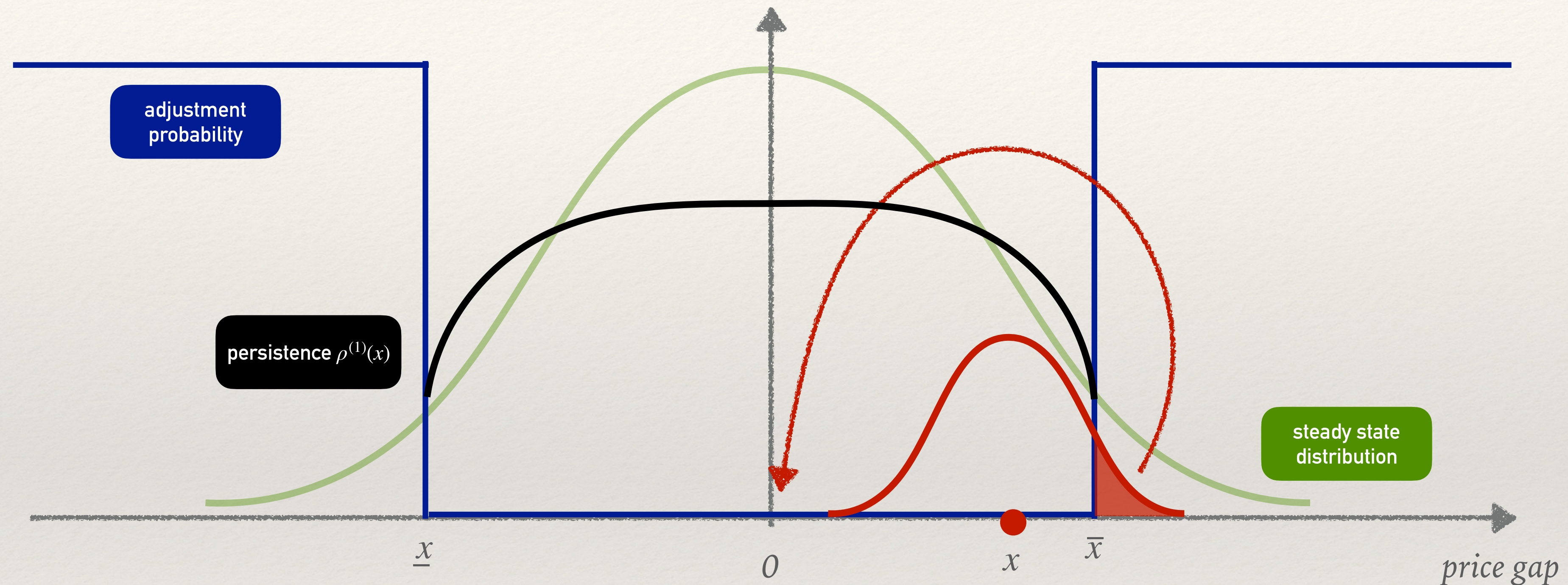
$$\pi_t = \kappa \widehat{mc}_t + \beta \mathbb{E}_t \pi_{t+1}$$

Menu cost

$$\pi_t \approx \tilde{\kappa} \widehat{mc}_t + \beta \mathbb{E}_t \pi_{t+1}$$

$$\tilde{\kappa} > \kappa$$

More mechanics of menu cost model



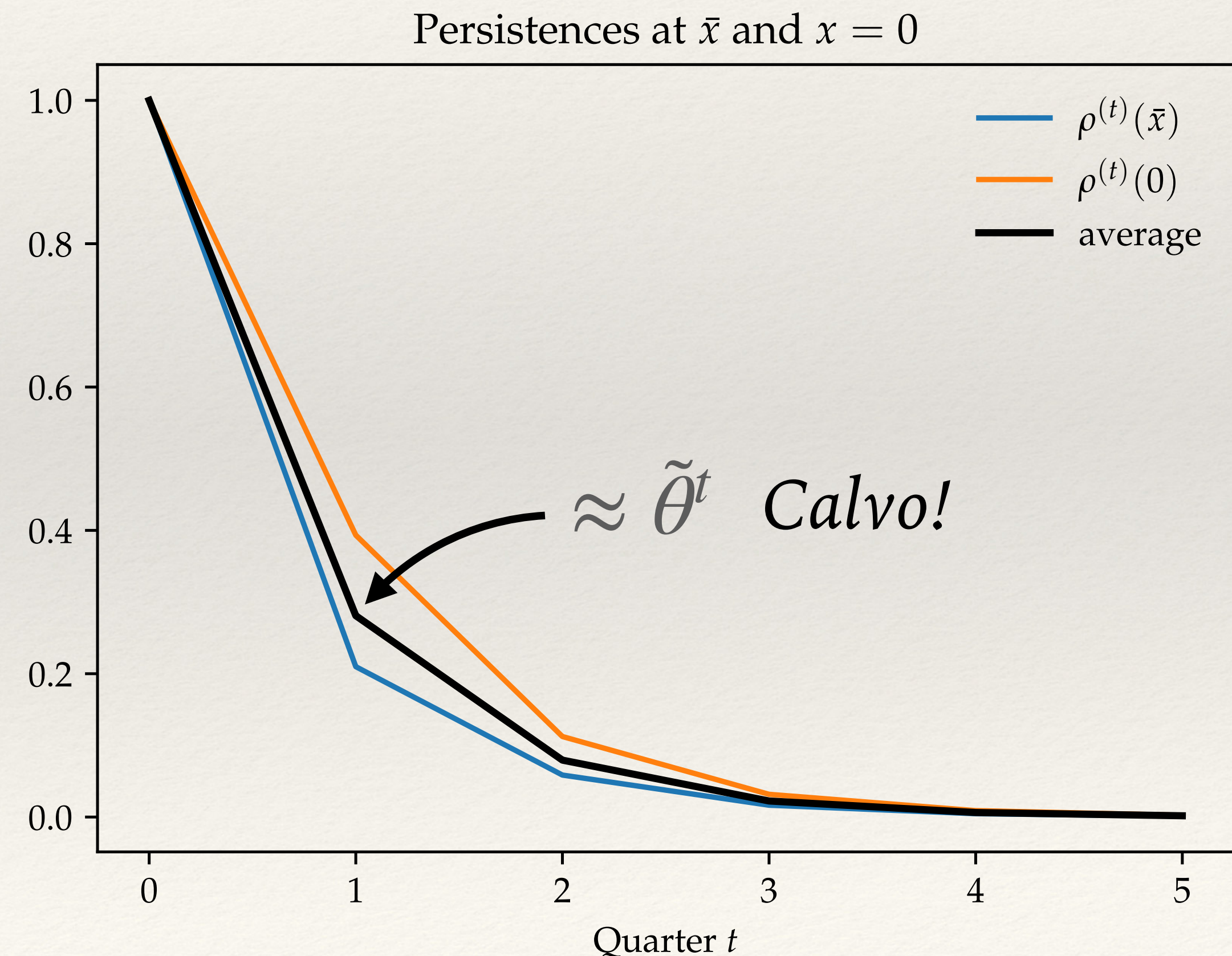
Define **persistence** of price gap x

$$\rho^{(t)}(x) \equiv \frac{\mathbb{E}_0[x_t | x_0 = x]}{x}$$

$$\rho^{(t)}(0) \equiv \lim_{x \rightarrow 0} \rho^{(t)}(x)$$

Exact equivalence result

- ❖ Menu cost model is **exactly the same** as mix of two time-dependent models
 - ❖ one with survival function equal to $\rho^t(0)$
 - ❖ one with survival function equal to $\rho^t(\bar{x})$
- ❖ Totally non-obvious!
- ❖ The two survival functions average to something close to exponential, $\sim$ Calvo!



Takeaway

- ❖ Menu cost models are great in that they **match the micro data!**
- ❖ But they **fail at matching macro data!** (even worse than Calvo...)
 - ❖ still no inertia, too forward looking, slope κ too high
- ❖ How can we make progress? One idea coming up after lunch...