Market Reforms at the Zero Lower Bound

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Motivation

- Labor and product market reforms are at the heart of the structural reform agenda advocated by many to boost performance of several advanced economies, notably in Europe and Japan.
- The theoretical case has been laid out by extensive literature that highlights long-term gains.
- No consensus on short-term impact, and even less on whether short-run effects depend on state of business cycle and how reforms interact with monetary (and fiscal) policy.

Motivation, Continued

- A central issue in the current economic environment involves the consequences of structural reforms when central banks face binding constraints on monetary policy easing, such as the so-called zero lower bound (ZLB) on nominal interest rates.
- At the heart of the debate lies the question whether reforms have important deflationary effects.
- As argued by Eggertsson (2010), in a liquidity trap, expectation of deflation increases real interest rates, thus depressing current demand further.
- Building on this insight, Eggertsson, Ferrero, and Raffo (2014, EFR) argue that structural reforms can have costly contractionary effects when monetary policy is constrained by the ZLB, since reforms fuel expectations of prolonged deflation.

Motivation, Continued

- Importantly, the analysis in EFR—and in several other papers that followed their approach—models market reforms as exogenous reductions in price and wage markups.
- This implies that reforms are automatically deflationary (and also that they depreciate the terms of trade and improve the external balance).
- However, from an empirical perspective, market regulation affects the incentives to create and destroy product and jobs by acting on barriers to entry and labor market legislation.
- Price and wage markup dynamics are endogenous outcomes of market reforms.
- The goal of this paper is to address the consequences of primitive changes in market regulation (rather than exogenous markup cuts) when the economy is in a deep recession that has triggered the ZLB on nominal interest rates.

Strategy

- Two-country, multi-sector model of a monetary union with endogenous producer entry and search and matching market frictions in the labor market.
  - Bilbiie, Ghironi, and Melitz (2012) and Ghironi and Melitz (2005).
  - Mortensen and Pissarides (1994) and den Haan, Ramey, and Watson (2000).
- Sticky prices and monetary policy, subject to ZLB constraint.
- We calibrate the model with parameter values from literature and to match features of macro data for euro area.

Strategy, Continued

- Then study dynamic response to:

1. product market reform: reduction in regulatory costs of entry in non-tradable sector;
   - Focus on non-tradable sector to explore idea that deregulation of profession/service sectors should propagate as cost-reduction throughout economy.
   - Different from Cacciatore, Duval, Fiori, and Ghironi (2015), Cacciatore and Fiori (2016), and Cacciatore, Fiori, and Ghironi (2015, 2016).
2. labor market reform: decline in firing costs or decline in generosity of unemployment benefits.

- Two alternative scenarios: Reforms are either implemented in normal times, assuming that the economy is at the steady state, or in the aftermath of a large adverse shock that depresses the economy and pushes monetary policy to the ZLB.

Results

- Our main conclusion is that while business cycle conditions at the time of deregulation matter for the adjustment, the presence of the ZLB does not per-se induce recessionary effects of market reforms.
- In fact, reforms can be more beneficial when the ZLB is binding, as observed for product market reform and joint deregulation of product and labor markets.
- This result reflects the fact that reforms do not have deflationary effects in the first place, and some are indeed inflationary, at least in the first phase of the transition.

Results, Continued

Intuition

- Consider first a reduction in barriers to producer entry.
- While such reform reduces price markups over time as a larger number of products results in higher substitutability, the downward pressure on prices is initially more than offset by two inflationary forces.

1. Lower entry barriers trigger entry of new producers, which increases demand for factors of production and thereby marginal costs.
2. Incumbent producers lay off less productive workers in response to increased competition.
   - Since remaining workers have higher wages on average, marginal labor costs rise.

- The latter effect also explains why lower firing costs—which induce firms to lay off less productive workers—are not deflationary either, even though layoffs reduce aggregate demand all else equal.
- Finally, while unemployment benefit cuts have a negative impact on wages and aggregate demand by weakening workers' outside option in the wage bargaining process, this deflationary effect is offset by the positive general equilibrium impact of the reform on labor demand, which increases wages other things equal.

Results, Continued

- Our results (and those in Cacciatore, Duval, Fiori, and Ghironi, 2016) highlight that prevailing business cycle conditions and not constraints on monetary policy represent the key dimension to consider when evaluating the short- to medium-run effects of market reforms.

- Moreover, contrary to the conventional view that emerges from reduced-form modeling of reforms as exogenous markup cuts, there is no simple across-the-board relationship between market reforms and the behavior of the real marginal costs.

- This is because reforms affect both supply and demand in complex ways, and the microeconomic underpinnings of the analysis are crucial to understand them.

Related Literature

- Long-run or two-period: Blanchard and Giavazzi (2003) and references in Cacciatore and Fiori (2016).
- Dynamics: Asturias, Hur, Kehoe, and Ruhl (2015), Cacciatore, Duval, Fiori, and Ghironi (2015, 2016), Cacciatore and Fiori (2016), Cacciatore, Fiori, and Ghironi (2015, 2016), Ghironi and Melitz (2005).
- Dynamics, state of the economy, and ZLB: Andres, Arce, and Thomas (2014), EFR, Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2011), Gerali, Notarpietro, and Pisani (2015), Vogel (2014).
  - Reduced-form structural reforms, no market dynamics. Very different implications for deflationary effects, terms of trade, and external balance.
  - Everaert and Schule (2008), Gomes (2014), and Varga and in't Veld (2011): EFR-style reforms in normal times in large-scale DSGE models.
- Unemployment benefits literature: Jung and Kuester (2015), Kroft and Notowidigdo (2011), Landais, Michaillat, and Saez (2010). More emphasis on firm hiring channel, as in Mitman and Rabinovich (2015), but full insurance within household and constant job search effort imply we do not incorporate insurance vs. moral hazard tradeoff.
- Positive effects of reducing unemployment benefits during recession consistent with evidence in Hagedorn, Karahan, Manovskii, and Mitman (2013) and Hagedorn, Manovskii, and Mitman (2015).

The Model: Household Preferences

- Monetary union of two countries, Home and Foreign.
- Cashless economy (Woodford, 2003).
- Representative home household maximizes:

$$E_t \left[\sum_{s=t}^{\infty} \beta^{s-t} \frac{\left(C_s^H - hC_{s-1}^H\right)^{1-\gamma}}{1-\gamma} \right],$$

  where $\beta \equiv$ discount factor and $h \equiv$ habit, both between 0 and 1; $\gamma > 0$.

- $C_t^H \equiv$ household consumption:

$$C_t^H \equiv C_t + h_p(1 - L_t).$$

  - $L_t \equiv$ mass of employed workers,
  - $h_p \equiv$ home production,
  - $C_t \equiv$ basket of domestic and imported consumption sub-bundles.

The Model: Household Preferences, Continued

- The consumption basket C_t aggregates a bundle of domestic and imported traded goods, C_t^T, and a bundle of non-tradable goods, C_t^N:

$$C_t = \left[(1-\alpha_N)^{\frac{1}{\phi_N}} \left(C_t^T\right)^{\frac{\phi_N - 1}{\phi_N}} + \alpha_N^{\frac{1}{\phi_N}} \left(C_t^N\right)^{\frac{\phi_N - 1}{\phi_N}} \right]^{\frac{\phi_N}{\phi_N - 1}}.$$

- Tradable consumption:

$$C_t^T = \left[(1-\alpha_X)^{\frac{1}{\phi_T}} \left(C_{D,t}^T\right)^{\frac{\phi_T - 1}{\phi_T}} + \alpha_X^{\frac{1}{\phi_T}} \left(C_{X,t}^{T*}\right)^{\frac{\phi_T - 1}{\phi_T}} \right]^{\frac{\phi_T}{\phi_T - 1}}.$$

- Home bias in tradable preferences.

The Model: Household Preferences, Continued

- Endogenous number of non-tradable product varieties available to consumers $c_t^N(\omega)$: $\Omega_t \in \Omega$.

- Aggregator C_t^N takes a translog form (Feenstra, 2003).

- Unit expenditure function on basket C_t^N given by:

$$\ln P_t^N = \frac{1}{2\sigma}\left(\frac{1}{N_t} - \frac{1}{\tilde{N}}\right) + \frac{1}{N_t}\int_{\omega\in\Omega_t} \ln p_t^N(\omega)\, d\omega + \frac{\sigma}{2N_t}\int_{\omega\in\Omega_t}\int_{\omega'\in\Omega_t} \ln p_t^N(\omega)\left(\ln p_t^N(\omega) - \ln p_t^N(\omega')\right) d\omega d\omega',$$

where $\sigma > 0 \equiv$ price elasticity of spending share on individual good, $N_t \equiv$ total number of products available at time t, $\tilde{N} \equiv$ mass of Ω, and $p_t^N(\omega) \equiv$ nominal price of good $\omega \in \Omega_t$.

- Property of translog preferences (in the symmetric equilibrium):

$$\theta_t^N \equiv -\frac{\partial \ln c_t^N}{\partial \ln\left(p_{\omega,t}^N / P_t\right)} = 1 + \sigma N_t.$$

The Model: Production

- Vertically integrated production sectors.
- Upstream sector: perfectly competitive firms use capital and labor to produce a non-tradable intermediate input Y_t^I.
  - Search and matching frictions in labor market.
- Downstream sectors:
  - Monopolistically competitive firms use Y_t^I to produce differentiated non-tradable varieties.
  - Perfectly competitive firms combine Y_t^I and differentiated non-tradable products to produce homogeneous tradable good.
  - Production structure consistent with Boeri at al. (2005):
    - Service industries key supplier of the manufacturing sector.

The Model: Intermediate Input Producers

- Firms post vacancies, V_t, to hire new workers, incurring real cost κ.
- Unemployed workers, U_t, search for jobs.
- Aggregate matching technology: $M_t = \chi U_t^{\varepsilon} V_t^{1-\varepsilon}$.
- Probability of filling a vacancy: $q_t \equiv M_t / V_t$; probability of becoming employed: $s_t \equiv M_t / U_t$.

The Model: Intermediate Input Producers, Continued

- Job i produces $Z_t z_t^i \left(k_t^i\right)^a$ units of output:
  - $Z_t \equiv$ aggregate productivity,
  - $k_t^i \equiv$ stock of capital allocated to the job,
  - $z_t^i \equiv$ idiosyncratic job-productivity shock with c.d.f. $G(z)$.

- The representative firm in this sector produces output

$$Y_t^I = Z_t L_t \frac{1}{1 - G(z_t^c)} \int_{z_t^c}^{\infty} z k_t^{\alpha}(z)\, g(z) dz,$$

  where $L_t \equiv$ measure of jobs within the firm, $k_t(z) \equiv$ capital allocated to job with productivity z, and $z_t^c \equiv$ threshold below which jobs that draw $z_t^i < z_t^c$ are not profitable and are destroyed.

- Firm incurs a real firing cost F_t (pure loss, not a transfer to the worker).

The Model: Intermediate Input Producers, Continued

- Perfect mobility of capital rented in competitive market implies that production can be rewritten as:

$$Y_t^I = Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha},$$

  where:

  - $\tilde{z}_t \equiv \left[\frac{1}{1-G(z_t^c)} \int_{z_t^c}^{\infty} z^{1/(1-\alpha)} g(z) dz\right]^{1-\alpha}$ (weighted) average job productivity,
  - $K_t = L_t \tilde{k}_t$, where $\tilde{k}_t \equiv \int_{z_t^c}^{\infty} k_t(z) g(z) dz / \left[1 - G(z_t^c)\right].$
  - See Cacciatore and Fiori (2016) for more details.

The Model: Intermediate Input Producers, Continued

- Producers chooses $(K_t,\, L_t,\, V_t,\, z_t^c)$ to maximize PDV of profits.

- Period t profits, d_t^I:

$$d_t^I \equiv \varphi_t Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha} - \tilde{w}_t L_t - r_t^K K_t - \kappa V_t - G(z_t^c)\,(1-\lambda)\,(L_{t-1} + q_{t-1} V_{t-1})\, F_t,$$

  where:

  - $\varphi_t \equiv$ price in units of consumption,
  - $\tilde{w}_t \equiv \int_{z_t^c}^{\infty} w_t(z) g(z) dz / \left[1 - G\left(z_t^c\right)\right]$ (weighted) average wage,
  - $r_t^K \equiv$ rental rate of capital,
  - $\lambda \equiv$ probability of exogenous job separation.

- Constraint: The law of motion of employment:

$$L_t = (1-\lambda)\left(1 - G\left(z_t^c\right)\right)\left(L_{t-1} + q_{t-1} V_{t-1}\right).$$

Job Creation

- $$\frac{\kappa}{q_t} = (1-\lambda) E_t \left\{ \beta_{t,t+1} \left[\left(1 - G\left(z_{t+1}^c\right)\right) \left((1-\alpha) \varphi_{t+1} \frac{Y_{t+1}^I}{L_{t+1}} - \tilde{w}_{t+1} + \frac{\kappa}{q_{t+1}} \right) - G\left(z_{t+1}^c\right) F_{t+1} \right] \right\}.$$
  - $\beta_{s,t} \equiv \beta^{s-t} u_{C^H,s} / u_{C^H,t} \equiv$ stochastic discount factor of Home households, who are assumed to own firms, where:
  $$u_{C^H,t} \equiv \left(C_t^H - h_C C_{t-1}^H\right)^{-\gamma} - h_C \beta E_t \left[\left(C_{t+1}^H - h_C C_t^H\right)^{-\gamma} \right].$$

- Marginal cost of posting vacancy $=$ marginal benefit:
  - With probability q_t, vacancy is filled; two events possible:
  - Either the new recruit fired in period $t+1$, and firm will pay firing cost, or match will survive job destruction, generating value for firm.
  - Marginal benefit of filled vacancy includes expected discounted savings on future vacancy posting, plus average profits generated by match.

The Model: Intermediate Input Producers, Continued

Job Destruction

$$(1-\alpha)\,\varphi_t \frac{Y_t^I}{L_t}\left(\frac{z_t^c}{\tilde{z}_t}\right)^{\frac{1}{1-\alpha}} - w\left(z_t^c\right) + \frac{\kappa}{q_t} = -F_t.$$

- Value to firm of job with productivity z_t^c must be equal to zero:
  - Contribution of match to current and expected future profits $=$ firm outside option—firing the worker, paying F_t.
  - When unprofitable jobs are terminated, firm loses current and expected profits it would have earned had it kept the laid-off workers.
  - But firm benefits from job destruction in the form of improved distribution of job productivities.

Capital

$$\alpha\varphi_t \frac{Y_t^I}{K_t} = r_t^K.$$

The Model: Intermediate Input Producers, Continued

Wage Bargaining

- Individual Nash bargaining: worker's exogenous bargaining weight η.
- Firm's outside option: firing the worker and posting a new vacancy.
- Worker's outside option: unemployment benefit from the government, b_t, and home production, h_p.
- In equilibrium:

$$
\begin{aligned}
w_t(z) \; = \; & \eta \left[(1-\alpha)\,\varphi_t \frac{Y_t^I}{L_t} \left(\frac{z}{\tilde{z}_t} \right)^{\frac{1}{1-\alpha}} + \kappa \frac{V_t}{U_t} + F_t - (1-\lambda)\,(1-s_t)\, E_t \beta_{t,t+1} F_{t+1} \right] \\
& + (1-\eta)\,(h_p + b_t)\,.
\end{aligned}
$$

The Model: Non-Tradable Output Producers

- Continuum of symmetric monopolistically competitive producers.
  - Endogenous number of producers: N_t.
- Producer ω faces demand:

$$y_t^N(\omega) = \sigma \ln\left(\frac{\bar{p}_t^N}{p_t^N(\omega)}\right)\frac{P_t^N Y_t^N}{p_t^N(\omega)},$$

where

$$\ln \bar{p}_t^N \equiv (1/\sigma N_t) + (1/N_t)\int_{\omega\in\Omega_t} \ln p_t^N(\omega)\, d\omega$$

is maximum price that producer can charge while still having a positive market share.

- Period profit:

$$d_t^N(\omega) = \left(\frac{p_t^N(\omega)}{P_t} - \varphi_t\right) y_t^N(\omega) - \frac{\Gamma_t^N(\omega)}{P_t}$$

- Price setting is subject to quadratic adjustment costs as in Rotemberg (1982): $\Gamma_t^N(\omega) \equiv \nu\left(\pi_t^N(\omega)\right)^2 p_t^N(\omega)\, y_t^N(\omega)/2$, $\nu \geq 0$, $\pi_t^N(\omega) \equiv \left(p_t^N(\omega)/p_{t-1}^N(\omega)\right) - 1$,

The Model: Non-Tradable Output Producers, Continued

- Optimal price setting (and symmetry across producers):

$$\frac{p_t^N}{P_t} = \frac{\theta_t^N}{\left(\theta_t^N - 1\right) \Xi_t^N} \varphi_t.$$

- Pro-competitive effect of entry: $\theta_t^N \equiv 1 + \sigma N_t$.

- Sticky prices imply:

$$\Xi_t^N \equiv 1 - \frac{\nu}{2} \left(\pi_{\omega,t}^N\right)^2 + \frac{\nu}{\theta_t^N - 1} \left\{ \left(\pi_{\omega,t}^N + 1\right) \pi_{\omega,t}^N - (1-\delta) E_t \left[\beta_{t,t+1} \left(\pi_{\omega,t+1}^N + 1\right) \pi_{\omega,t+1}^N \frac{\rho_{t+1}^N Y_{t+1}^N}{\rho_t^N Y_t^N} \frac{N_t}{N_{t+1}} \right] \right\}.$$

The Model: Non-Tradable Output Producers, Continued

Entry

- Sunk entry cost: $f_{E,t} \equiv f_{R,t} + f_{T,t}$ in units of final consumption.
  - $f_{R,t} \equiv$ red tape,
  - $f_{T,t} \equiv$ technological entry cost.
- Exogenous exit shock with probability δ at the end of each period.

The Model: Non-Tradable Output Producers, Continued

- Entry decision:

$$e_t^N = f_{E,t},$$

where

$$e_t^N = E_t \left[\sum_{s=t+1}^{\infty} \beta_{t,s} \left(1-\delta\right)^{s-t} d_s^N \right],$$

and $d_t^N \equiv \left(p_t^N / P_t - \varphi_t\right) y_t^N =$ period firm profit (symmetric equilibrium).

- Number of producers (time to build):

$$N_t = (1-\delta)(N_{t-1} + N_{E,t-1}),$$

where $N_{E,t} \equiv$ number of entrants.

The Model: Tradable Output Producers

- Production function:

$$Y_t^T = \left(Y_{T,t}^I\right)^{\xi} \left(Y_{T,t}^N\right)^{1-\xi},$$

  where:

  – $Y_{T,t}^I \equiv$ intermediate input,

  – $Y_{T,t}^N \equiv$ non-tradable goods used in tradable good production.

The Model: Tradable Output Producers, Continued

- Perfect competition $\Longrightarrow$ price of output as given, both in domestic and export market.
- No arbitrage $\Longrightarrow$ price of export (in the common currency) is $P^T_{X,t} = \tau_t P^T_{D,t}$, where τ_t is an iceberg trade cost
- F.o.c.'s for $Y^I_{T,t}$ and $Y^N_{T,t}$ imply, respectively:

$$\xi \rho^T_{D,t} \left(C^T_{D,t} + \tau_t C^T_{X,t} \right) = \varphi_t Y^I_{T,t},$$

$$(1 - \xi) \rho^T_{D,t} \left(C^T_{D,t} + \tau_t C^T_{X,t} \right) = \rho^N_t Y^N_{T,t},$$

where ρ's are relative prices (in units of consumption).

Household's Intertemporal Choices

- Owns capital stock, rented competitively to intermediate input producers, and invests in two financial assets:
  - shares in mutual fund of non–tradable-output firms,
  - non-contingent, internationally traded bond denominated in units of currency.
- Stock market investment is the mechanism through which household savings are made available to prospective entrants to cover entry costs.

Household's Intertemporal Choices, Continued

- Convex investment adjustment costs and variable capital utilization (set by household):
  - Effective capital rented to firms, $K_t = u_{K,t}\tilde{K}_t$, where $u_{K,t} \equiv$ utilization rate.
  - Increases in utilization imply faster depreciation: $\delta_{K,t} \equiv \varkappa u_{K,t}^{1+\varsigma} / (1+\varsigma)$.
    - Greenwood, Hercowitz, and Huffman (1988), Burnside and Eichenbaum (1996).
- Law of motion of physical capital:

$$\tilde{K}_{t+1} = (1-\delta_{K,t})\tilde{K}_t + I_{K,t}\left[1 - \frac{\nu_K}{2}\left(\frac{I_{K,t}}{I_{K,t-1}} - 1\right)^2\right].$$

Household's Intertemporal Choices, Continued

- Euler equation for capital accumulation:

$$\zeta_{K,t} = E_t \left\{ \beta_{t,t+1} \left[r_{t+1}^K u_{K,t+1} + (1 - \delta_{K,t+1}) \zeta_{K,t+1} \right] \right\},$$

  where $\zeta_{K,t} \equiv$ shadow value of capital (in units of consumption)

- F.o.c. for investment $I_{K,t}$:

$$\begin{aligned} \zeta_{K,t}^{-1} \; &= \left[1 - \frac{\nu_K}{2} \left(\frac{I_{K,t}}{I_{K,t-1}} - 1 \right)^2 - \nu_K \left(\frac{I_{K,t}}{I_{K,t-1}} - 1 \right) \left(\frac{I_{K,t}}{I_{K,t-1}} \right) \right] \\ &+ \nu_K \beta_{t,t+1} E_t \left[\frac{\zeta_{K,t+1}}{\zeta_{K,t}} \left(\frac{I_{K,t+1}}{I_{K,t}} - 1 \right) \left(\frac{I_{K,t+1}}{I_{K,t}} \right)^2 \right]. \end{aligned}$$

- F.o.c. for capital utilization $u_{K,t}$:

$$r_t^K = \varkappa u_{K,t}^{1+\varsigma} \zeta_{K,t}.$$

Household's Intertemporal Choices, Continued

- Euler equation for share holdings:

$$e_t^N = (1-\delta) E_t \left[\beta_{t,t+1} \left(d_{t+1}^N + e_{t+1}^N \right) \right],$$

  – $e_t^N \equiv$ real price of a share (claim to future profits).

- Euler equations for bond holdings:

$$1 + \psi a_{t+1} + \Lambda_{a,t} = (1 + i_{t+1}) E_t \left(\frac{\beta_{t,t+1}}{1 + \pi_{t+1}^C} \right),$$

  – $\psi \equiv$ scale parameter in cost of adjusting bond holdings ($\psi a_{t+1}^2 / 2$),

  – $i_t \equiv$ nominal interest rate on bond holdings between $t-1$ and t, set by the central bank at $t-1$,

  – $\pi_t^C \equiv$ Home CPI inflation rate, $(P_t/P_{t-1}) - 1$,

  – $\Lambda_{a,t} \equiv$ risk-premium shock that affects demand for (nominally) risk-free assets, $AR(1)$ with i.i.d. Normal innovations.

    · As in Smets and Wouters (2007) and subsequent literature, $\Lambda_{a,t}$ appended to bond Euler equation to generate liquidity trap.

    · For our exercise, we assume $\Lambda_{a,t} = \Lambda_{a,t}^*$ in each period.

Some Equilibrium Relations

- Aggregate demand of final consumption basket $=$ market consumption $+$ investment in physical capital $+$ costs of product creation, job creation, and job destruction:

$$Y_t^C = C_t + I_{K,t} + N_{E,t} f_{E,t} + \kappa V_t + \frac{G\left(z_t^c\right) L_t}{1 - G\left(z_t^c\right)} F_t.$$

- Market clearing:

$$\begin{aligned} Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha} &= \exp\left\{\frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t}\right\} Y_t^N + Y_{T,t}^I, \\ Y_t^N &= \left(1 - \frac{\nu}{2}\left(\pi_{\omega,t}^N\right)^2\right)^{-1} \left(C_t^N + Y_{T,t}^N\right), \\ C_{D,t}^T + \tau_t C_{X,t}^T &= \left(Y_{T,t}^I\right)^{\xi} \left(Y_{T,t}^N\right)^{1-\xi}. \end{aligned}$$

- Net foreign assets:

$$a_{t+1} = \frac{1 + i_t}{1 + \pi_t^C} a_t + TB_t,$$

where $TB_t \equiv Q_t \rho_{X,t}^T C_{X,t}^T - \rho_{Xt}^{T*} C_{X,t}^{T*}$ is trade balance, and $Q_t / Q_{t-1} = \left(1 + \pi_t^{C*}\right) / \left(1 + \pi_t^C\right)$.

Monetary Policy

- We take explicitly into account the possibility that the nominal interest rate cannot fall below some lower bound i^{zlb}, so that in each period $i_{t+1} \geqslant i^{zlb}$.

- Therefore, the nominal interest rate set by the central bank of our model monetary union satisfies:

$$1 + i_{t+1} = \max\left\{1 + i^{zlb}, (1 + i_t)^{\varrho_i} \left[(1 + i)\left(1 + \tilde{\pi}^U_{C,t}\right)^{\varrho_\pi} \left(\tilde{Y}^U_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}\right\}.$$

  - $\tilde{\pi}^U_{C,t} \equiv \tilde{\pi}^{\gamma_\pi}_{C,t} \tilde{\pi}^{*1-\gamma_\pi}_{C,t}$ is the data-consistent, union-wide CPI inflation, and $\tilde{Y}^U_{g,t} \equiv \tilde{Y}^{\gamma_{\tilde{Y}}}_{g,t} \tilde{Y}^{*1-\gamma_{\tilde{Y}}}_{g,t}$ is the data-consistent, union-wide GDP gap.

  - Data-consistent $=$ purged of pure variety effect.

TABLE 2: CALIBRATION

Variety elasticity	$\sigma = 0.34$	Unemployment benefit	$b = 0.33$
Risk aversion	$\gamma = 1$	Firing costs	$F = 0.06$
Discount factor	$\beta = 0.99$	Matching function elasticity	$\varepsilon = 0.5$
EOS, home and foreign goods	$\phi_T = 1.5$	Home bias	$1 - \alpha_T = 0.6$
EOS, tradables and non-tradables	$\phi_N = 0.5$	Share of non-tradables consumption	$\alpha_N = 0.80$
Share of non-tradables in manufacturing	$\xi = 0.6$	Bond adjustment cost	$\psi = 0.0025$
Technological entry cost	$f_T = 0.73$	Workers' bargaining power	$\eta = 0.5$
Regulation entry cost	$f_R = 1.09$	Home production	$h_P = 0.6$
Plant exit	$\delta = 0.004$	Matching efficiency	$\chi = 0.45$
Investment adjustment costs	$\nu = 0.16$	Vacancy cost	$k = 0.11$
Capital depreciation rate	$\delta_K = 0.025$	Exogenous separation rate	$\lambda = 0.036$
Capital share	$\alpha = 0.33$	Lognormal shape	$\sigma_{z_i} = 0.14$
Capital utilization, scale	$\varkappa = 0.035$	Lognormal log-scale	$\mu_{z_i} = 0$
Consumption habits	$h_C = 0.6$	Capital utilization, convexity	$\varsigma = 0.41$
Interest Rate Smoothing	$\varrho_\iota = 0.87$	Inflation Response	$\varrho_\pi = 1.93$
GDP Gap Response	$\varrho_i = 0.075$	Zero lower bound	$i^{zlb} = 0.01$

Market Reforms

- Permanent change in product and labor market policy parameters (in one country or both).
- Product market reform: reduction of red tape entry costs, f_R.
- Labor market reform:
  - reduction of firing costs, F,
  - reduction of unemployment benefit replacement rate, $b/\tilde{w}$ (the replacement rate).
- Reform size: from average levels in the euro area to corresponding U.S. level.
- We contrast deregulation in normal times vs. recession that causes the nominal interest rate to reach the ZLB.

Liquidity Trap!

- Assume the risk-premium shock is realized at time 0.
- We calibrate the size of the shock to reproduce the peak-to-trough decline of euro-area output of about 4 percent following the collapse of Lehman Brothers in September 2008.
- We set the persistence of the shock such that, in the absence of market reforms, the ZLB is binding for approximately two years.

Liquidity Trap! Continued

- Exogenous reduction in $\Lambda_{a,t}$ lowers the marginal cost of saving in the risk-free bond, thereby increasing the incentive to save through this vehicle rather than via capital accumulation or product creation.
- As households demand more bonds, consumption, investment in physical capital, and producer entry fall.
- In turn, lower aggregate demand results in lower production in both tradable and non-tradable sectors, and higher unemployment.
- The central bank immediately cuts the nominal interest rate to the ZLB and keeps this accommodative stance for 8 quarters.
- As the shock slowly reverts back, the central bank smoothly increases the policy rate toward its long-run value.
- Consumption, output, and GDP recover.

Market Reforms at the Zero Lower Bound

- We assume that at quarter 0 both Home and Foreign are hit by the symmetric risk-premium shock described above.
- At quarter 1, there is a permanent change in regulation.
- As before, we consider a permanent reduction in barriers to entry, firing costs, and unemployment benefits, and we treat this policy shock as unanticipated.
- We construct the net effect of deregulating markets in a recession as the difference between the impulse responses following deregulation and the impulse responses following the risk-premium shock in the absence of market reform.

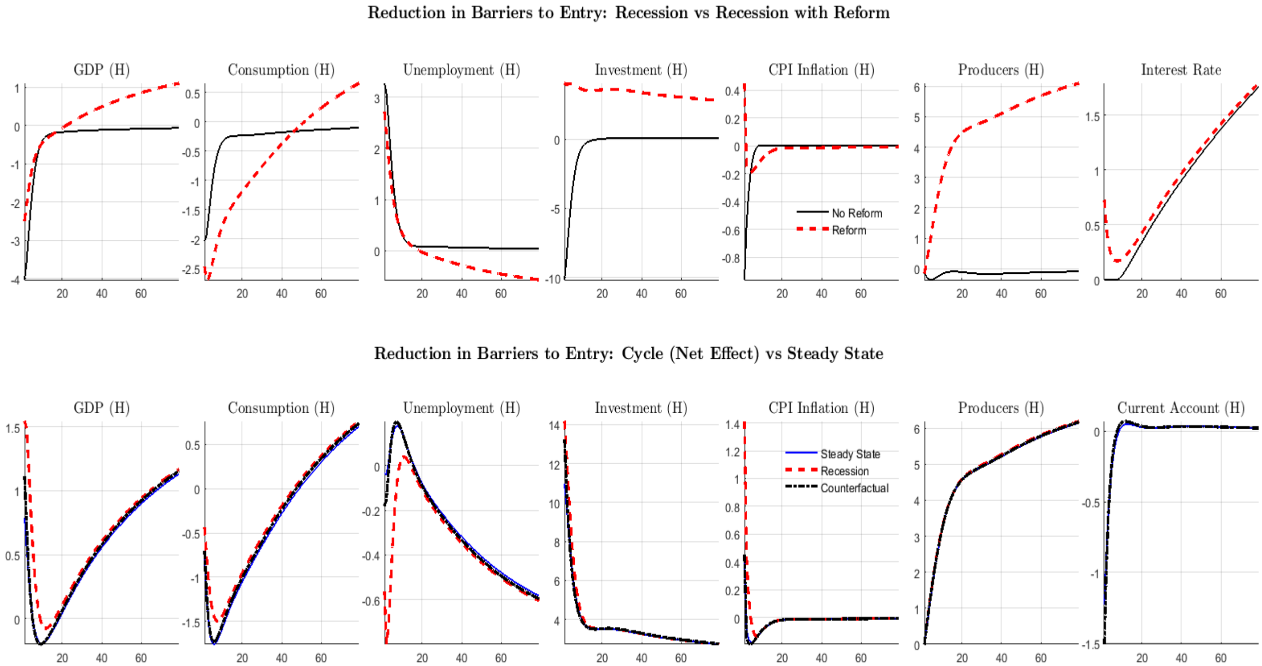

Figure 1. *Top panel*: recession (continuos lines) versus recession followed by product market reform (dashed lines); *Bottom panel*: net effect of product market reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

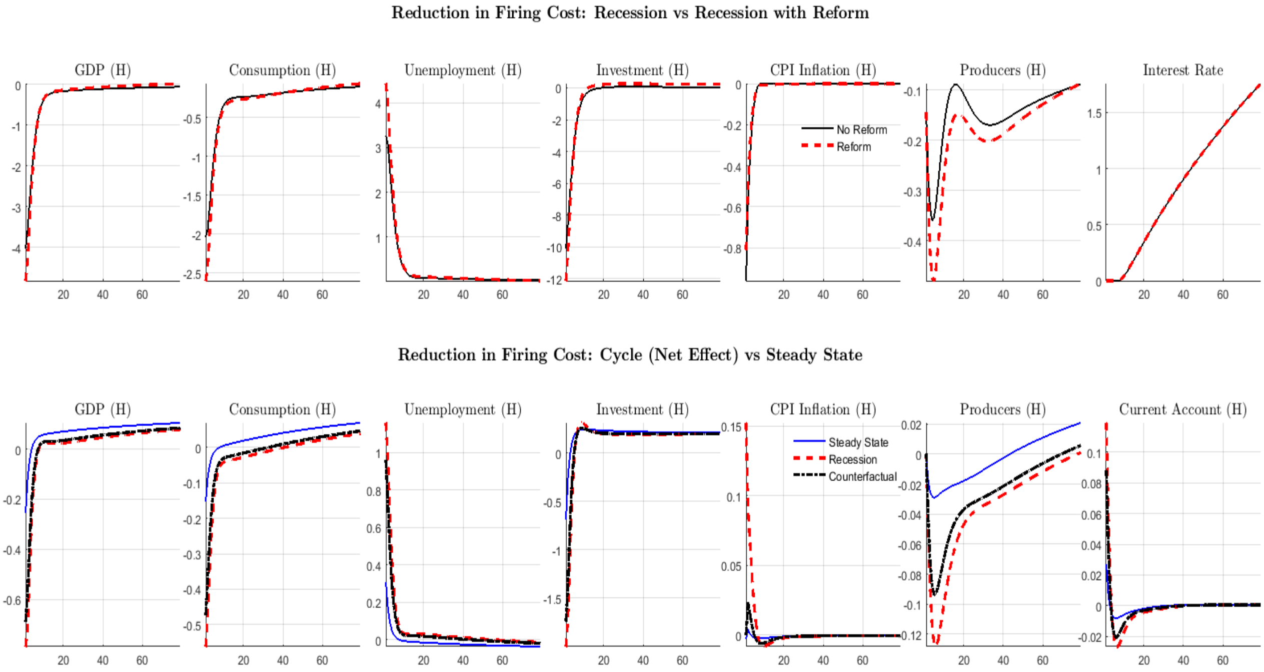

Figure 2. *Top panel*: recession (continuos lines) versus recession followed by firing cost reform (dashed lines); *Bottom panel*: net effect of firing cost reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

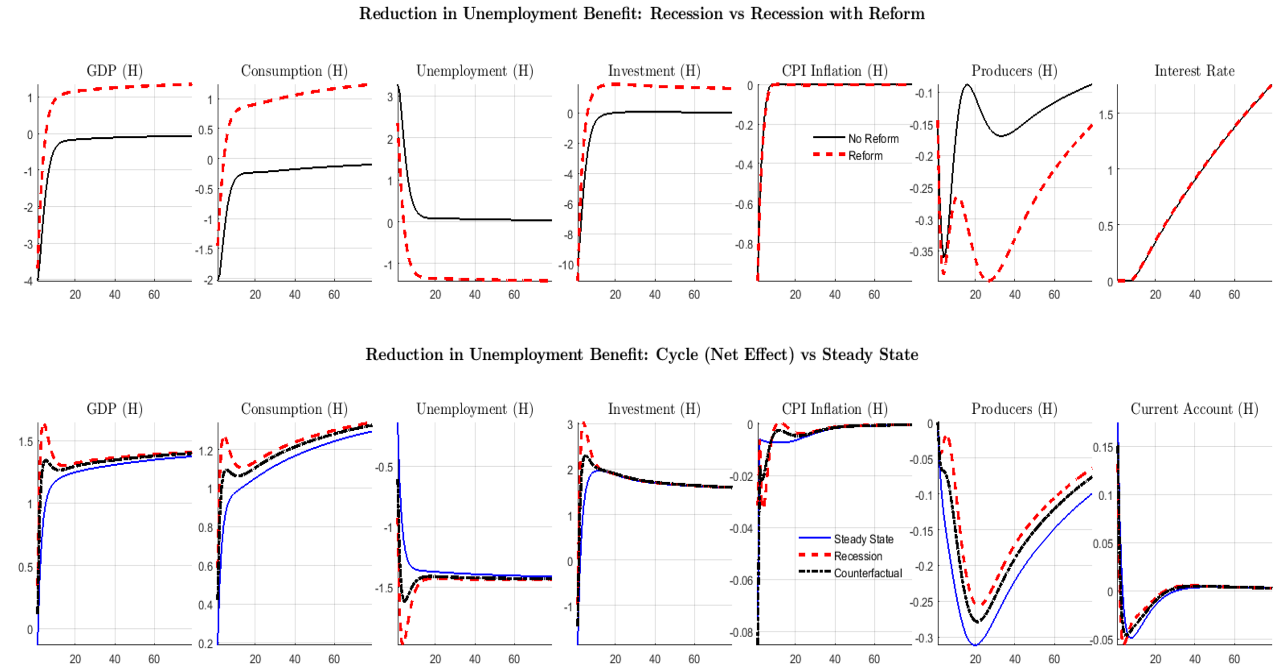

Figure 3. *Top panel*: recession (continuos lines) versus recession followed by unemployment benefit reform (dashed lines); *Bottom panel*: net effect of unemployment benefit reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

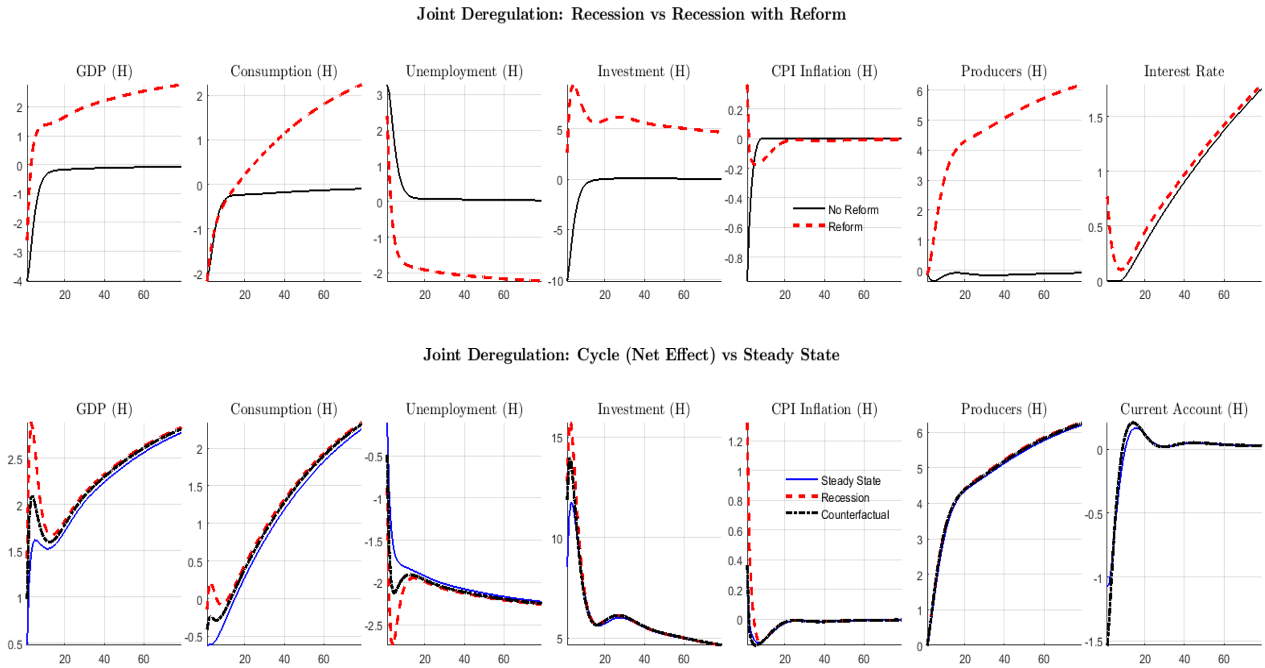

Figure 4. *Top panel*: recession (continuos lines) versus recession followed by joint product and labor market reform (dashed lines); *Bottom panel*: net effect of joint product and labor market reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

Conclusions

- We developed a model with micro-level product and labor market dynamics to study the consequences of product and labor market reforms and their interaction with monetary policy when the latter is constrained by the ZLB
- Micro matters! Conclusions are quite different from the implications of reduced-form modeling of structural reforms as exogenous markup cuts.
- The ZLB should not be taken as reason to delay structural reforms.

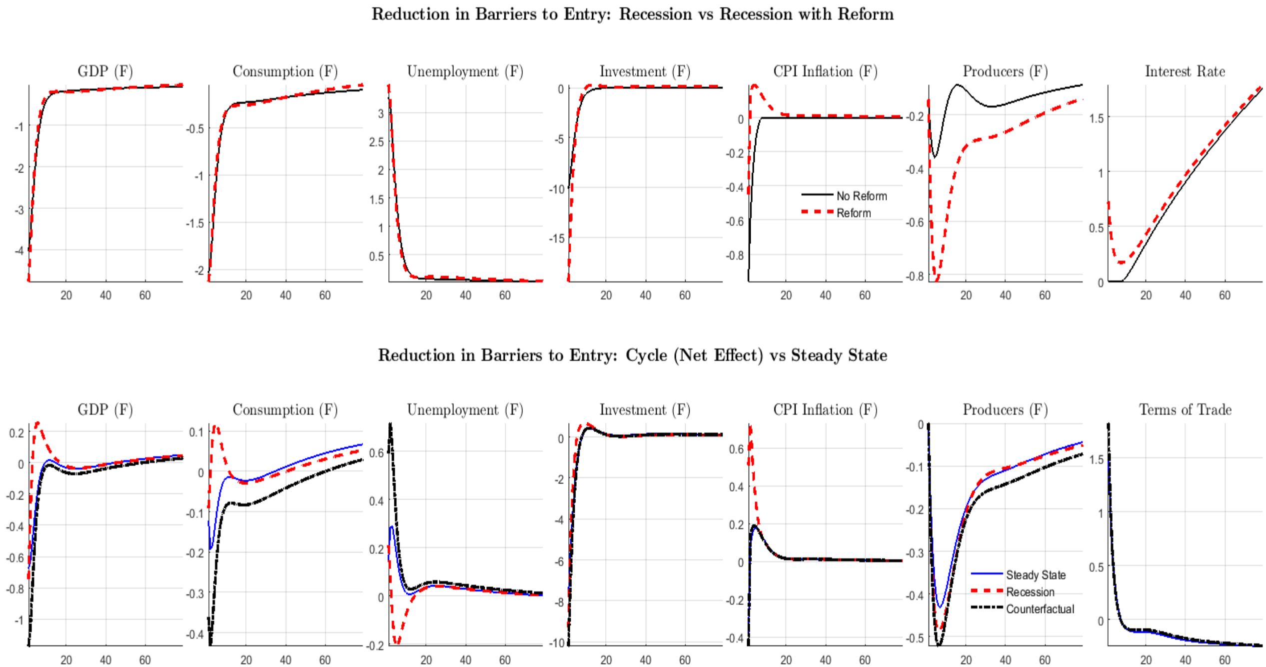

Figure A1. Foreign dynamics following Home deregulation. *Top panel*: recession (continuos lines) versus recession followed by product market reform (dashed lines); *Bottom panel*: net effect of product market reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

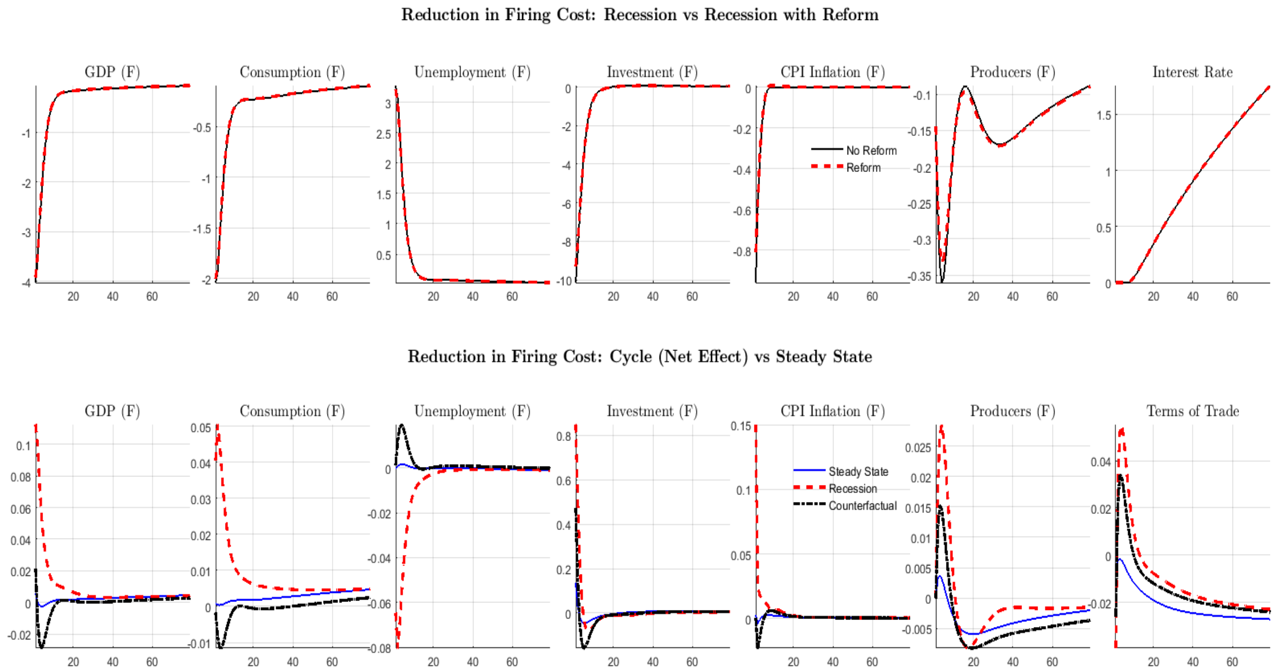

Figure A.2. Foreign dynamics following Home firing cost reform. *Top panel*: recession (continuos lines) versus recession followed by firing cost reform (dashed lines); *Bottom panel*: net effect of firing cost reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

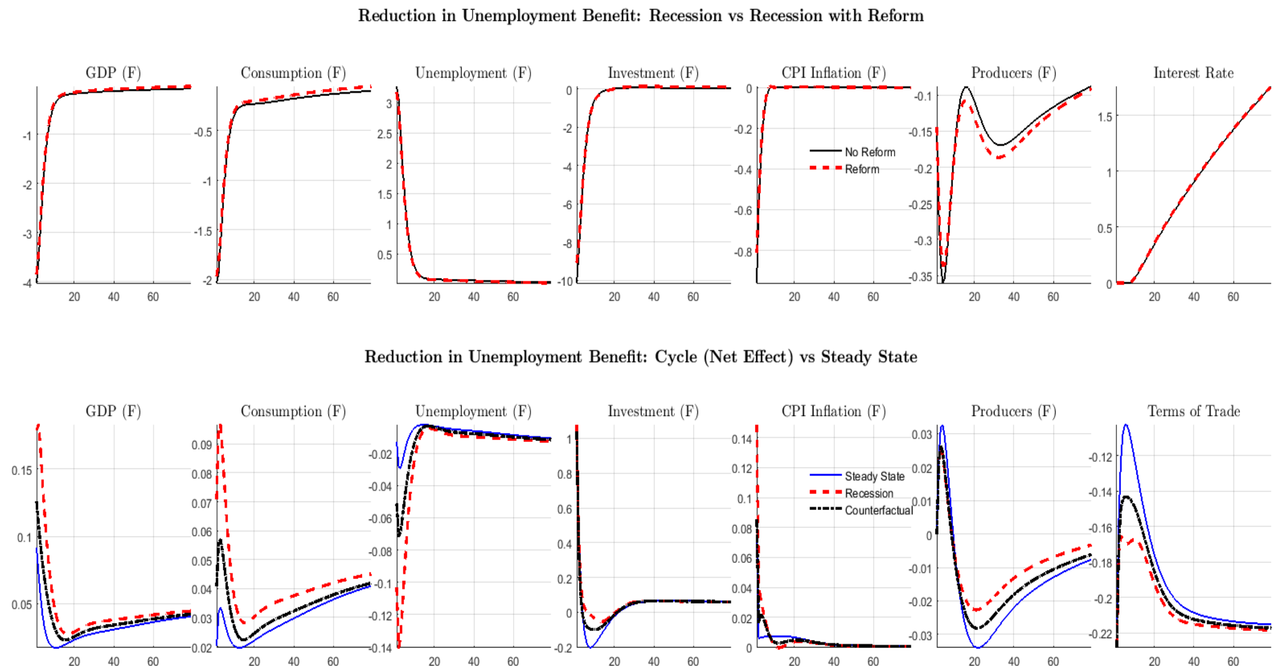

Figure A.3. Foreign dynamics following Home unemployment benefit reform. *Top panel*: recession (continuos lines) versus recession followed by unemployment benefit reform (dashed lines); *Bottom panel*: net effect of unemployment benefit reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

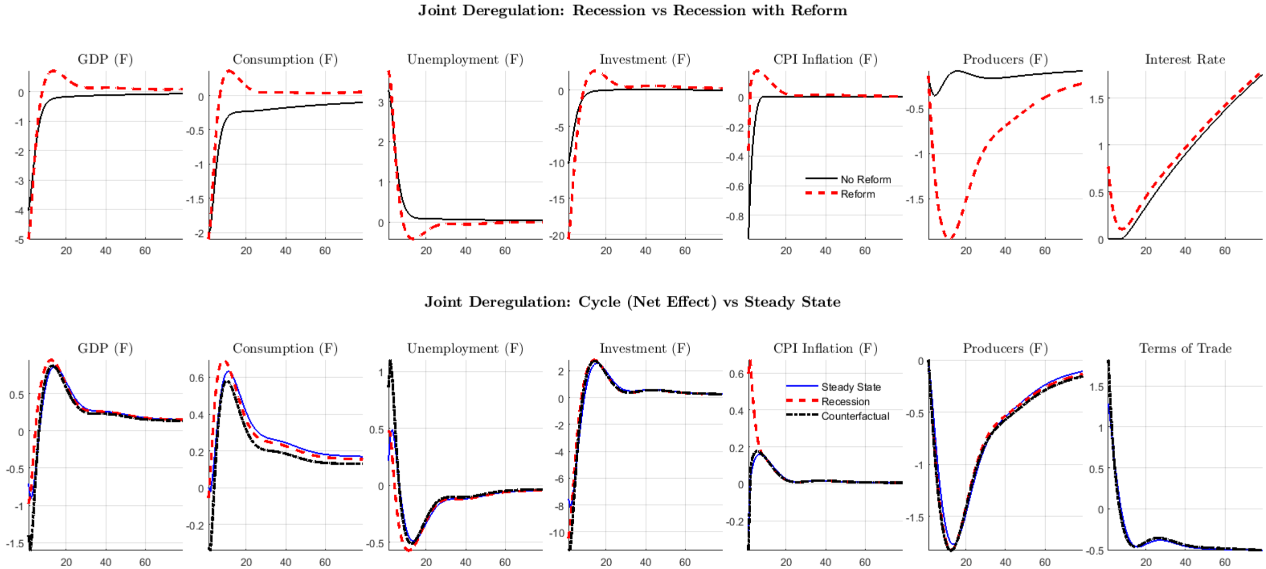

Figure A.4. Foreign dynamics following Home joint reform in product and labor market. *Top panel*: recession (continuos lines) versus recession followed by joint product and labor market reform (dashed lines); *Bottom panel*: net effect of joint product and labor market reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

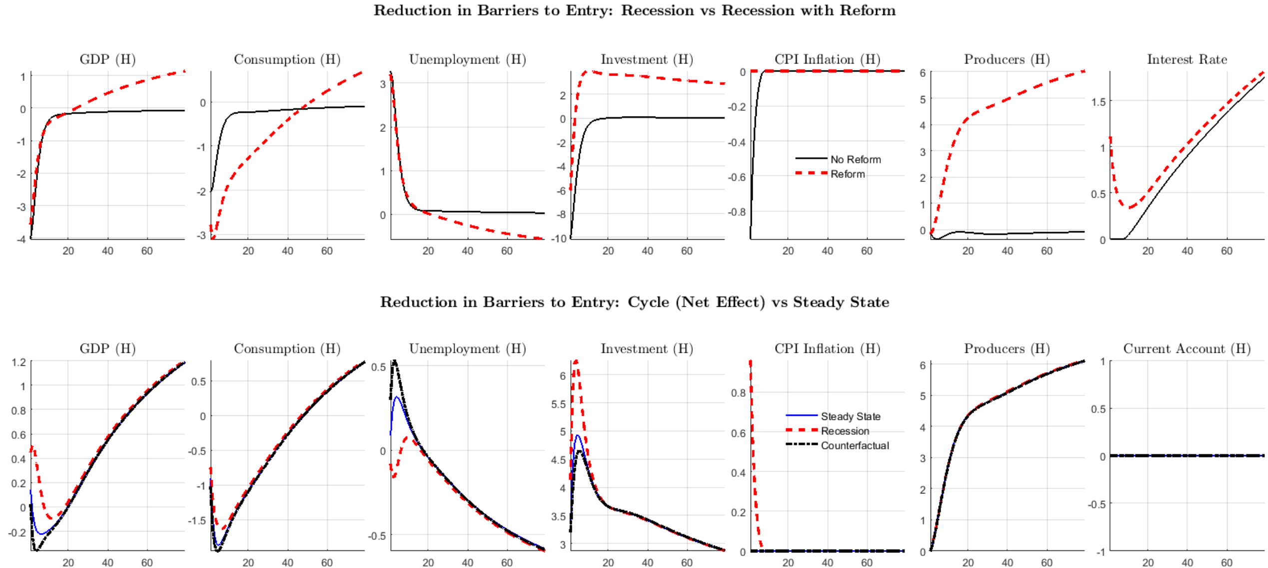

Figure A.5. *Top panel*: recession (continuos lines) versus recession followed by symmetric product market reform (dashed lines); *Bottom panel*: net effect of symmetric product market reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

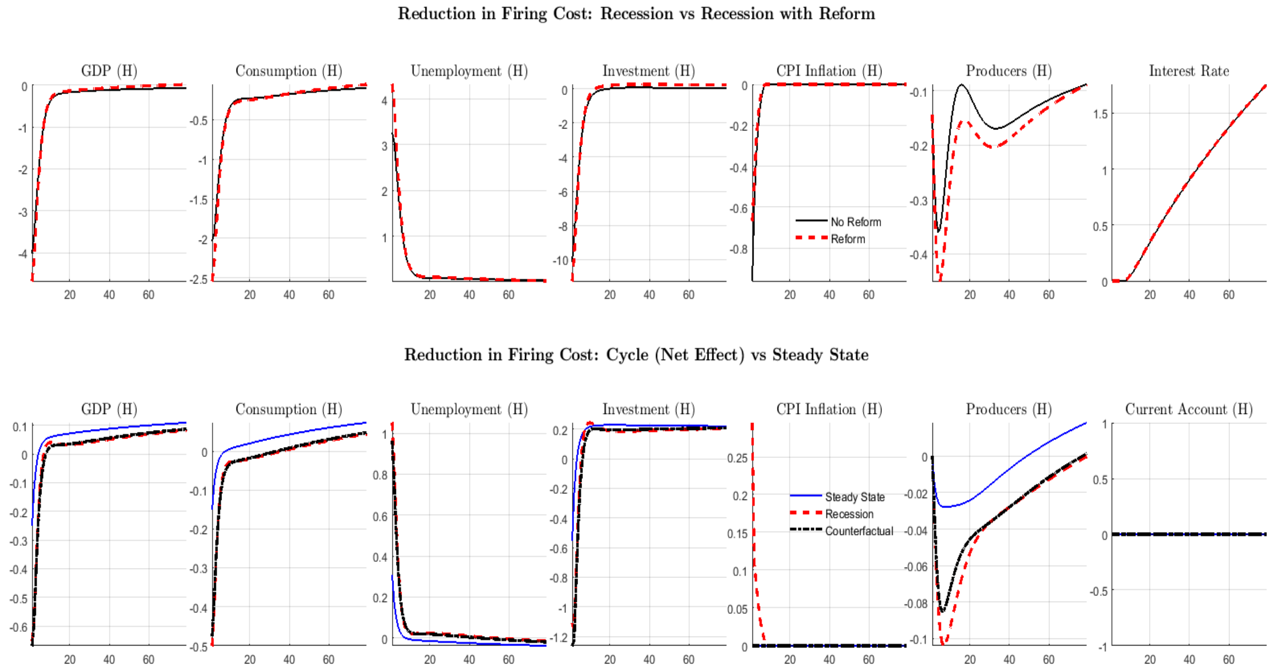

Figure A.6. *Top panel*: recession (continuos lines) versus recession followed by symmetric firing cost reform (dashed lines); *Bottom panel*: net effect of firing cost reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

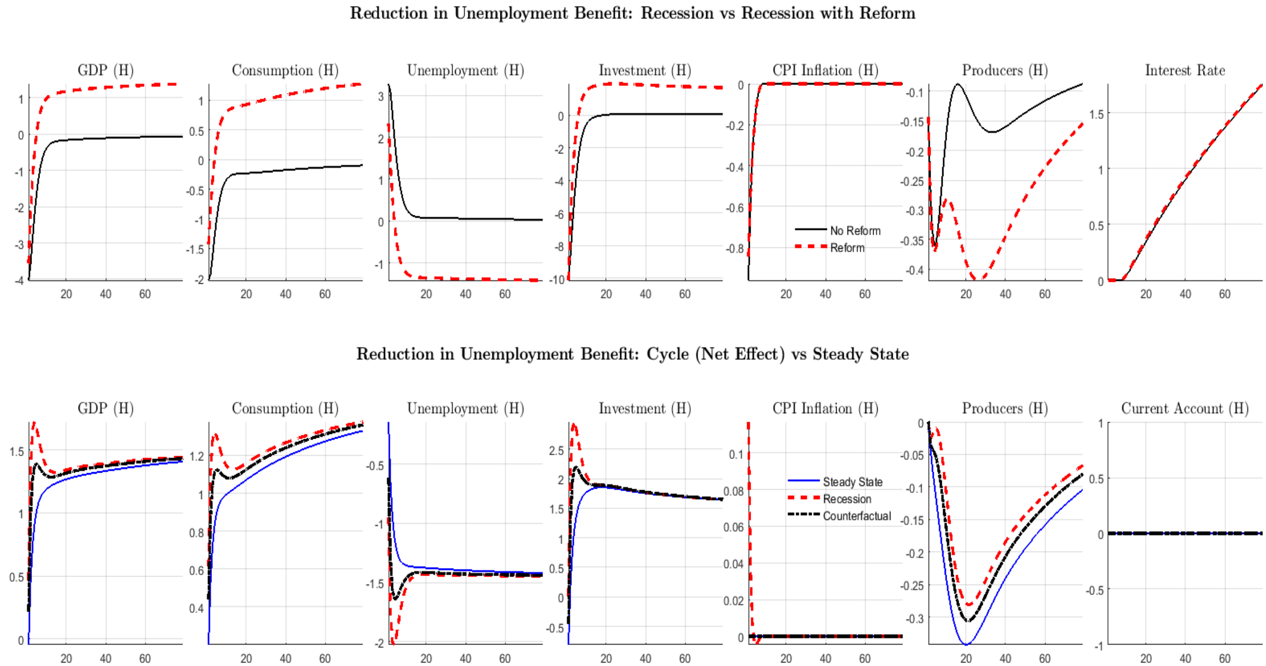

Figure A.7. *Top panel*: recession (continuos lines) versus recession followed by symmetric unemployment benefit reform (dashed lines); *Bottom panel*: net effect of unemployment benefit reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.

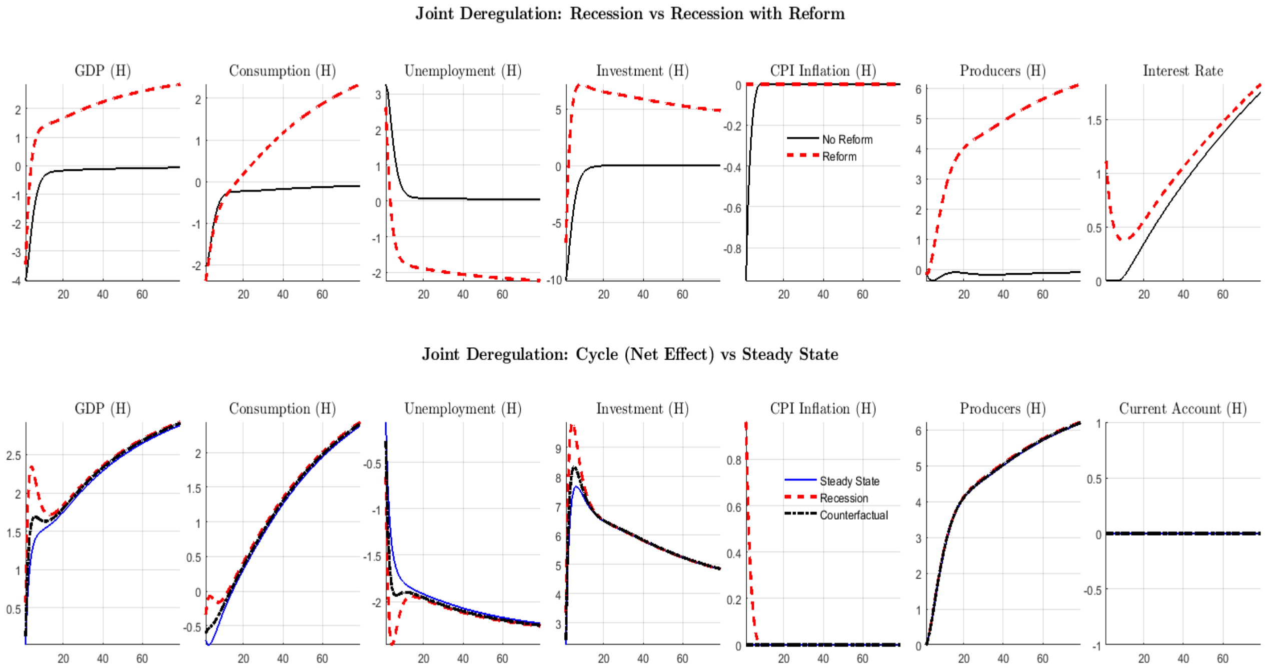

Figure A.8. *Top panel*: recession (continuos lines) versus recession followed by symmetric joint product and labor market reform (dashed lines); *Bottom panel*: net effect of joint product and labor market reform in normal times (continuos lines), in a recession with binding ZLB (dashed lines), and in a recession where the interest rate is allowed to violate the ZLB (dotted lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.