Trade, Unemployment, and Monetary Policy

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Motivation

"I would like to know how the macroeconomic model that I more or less believe can be reconciled with the trade models that I also more or less believe. [...] What we need to know is how to evaluate the microeconomics of international monetary systems. Until we can do that, we are making policy advice by the seat of our pants."

Paul R. Krugman (1995), "What Do We Need to Know about the International Monetary System?" in Peter B. Kenen, ed., *Understanding Interdependence*, Princeton U Press.

Motivation, Continued

- How does trade integration affect incentives for international monetary cooperation?

- How does trade integration affect incentives to peg the exchange rate?

- Standard argument: Trade integration makes cooperation (or a peg) more desirable.

This Paper

- We re-examine these classic questions in a two-country model that incorporates the standard ingredients of the current workhorse trade and macro frameworks:
  - heterogeneous firms and endogenous producer entry in domestic and export markets (Melitz, 2003; Ghironi and Melitz, 2005),
  - labor market frictions (Diamond,1982; and Mortensen and Pissarides, 1994),
  - dynamic, stochastic, general equilibrium.

Results: Validation

- The model reproduces empirical regularities for the U.S. and international business cycle, including increased comovement following trade integration.
  - In the long run, trade integration results in empirically plausible reallocation of market shares across producers.

Results: Policy

1. When trade linkages are weak, the optimal policy is inward looking but requires significant departures from price stability both in the long run and over the business cycle.

2. As trade integration reallocates market share toward more productive firms, the need of positive inflation to correct long-run distortions is reduced.

3. Increased business cycle synchronization implies that fluctuations induced by country-specific shocks have a more global nature.

- – Appropriately designed, inward-looking interest rate rules can still replicate the constrained efficient allocation and the need of cooperation remains muted relative to such rules.

  – However, historical (Fed) policy behavior implies inefficient fluctuations in cross-country demand, inducing larger welfare costs when trade linkages are strong.

    · In the case of a peg, welfare costs are larger for the center country under trade integration.

  – Results do not depend on producer versus local currency pricing or whether optimized Taylor rules are replaced by unrestricted optimal non-cooperative behavior.

Related Literature

- Non-microfounded: Canzoneri and Henderson (1991), Persson and Tabellini (1995)...

- Microfounded, New Keynesian: Benigno and Benigno (2003, 2006), Campolmi and Faia (2009), Canzoneri, Cumby, and Diba (2005), Clarida, Galí, and Gertler (2001), Corsetti and Pesenti (2001, 2005), Corsetti, Dedola, and Leduc (2012), Devereux and Engel (2003), Galí and Monacelli (2005), Lombardo and Ravenna (2011), Obstfeld and Rogoff (2002), Sutherland (2004)...

The Model

- Two countries: Home and Foreign.

- Cashless economy as in Woodford (2003).

- Each country populated by a unit mass of atomistic households.

- Each household is an extended family with a continuum of members along the unit interval.

- In equilibrium, some family members are unemployed, while some others are employed.

- Perfect insurance within the household $\Rightarrow$ no *ex post* heterogeneity across individual members (Andolfatto, 1996; Merz, 1995).

Household Preferences

- Representative home household maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) - l_t v(h_t)], \quad \beta \in (0,1).$$

  - $C_t =$ consumption basket, $l_t =$ number of employed workers, $h_t =$ hours worked by each employed worker.

- C_t aggregates consumption of imperfectly substitutable Home and Foreign "sectoral" consumption outputs (or bundles of product features) in Dixit-Stiglitz form:

$$C_t = \left[\int_0^1 C_t(i)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}}, \quad \phi > 1.$$

- Consumption-based price index:

$$P_t = \left[\int_0^1 P_t(i)^{1-\phi} di \right]^{\frac{1}{1-\phi}},$$

where $P_t(i)$ is the price index for sector i.

Production

- Two vertically integrated production sectors in each country.

- Upstream sector: Perfectly competitive firms use labor to produce a non-tradable intermediate input.

- Downstream sector: Each consumption-producing sector i is populated by a representative monopolistically competitive multi-product firm that purchases intermediate input and produces differentiated varieties of its sectoral output.
  - In equilibrium, some of these varieties are exported while the others are sold only domestically.

- This production structure greatly simplifies the introduction of labor market frictions and sticky prices.

Intermediate Goods Production

Labor Market Frictions

- Unit mass of intermediate producers.

- Each of them employs a continuum of workers.

- Labor markets are characterized by DMP search and matching frictions.

- To hire new workers, firms need to post vacancies, incurring a cost of κ units of consumption per vacancy posted.

- Let $U_t =$ aggregate unemployment and $V_t =$ aggregate vacancies $\Rightarrow$ matching technology generates aggregate matches

$$M_t = \chi U_t^{1-\varepsilon} V_t^{\varepsilon}, \quad \chi > 0, 0 < \varepsilon < 1.$$

- Each firm meets unemployed workers at rate $q_t \equiv M_t / V_t$.

Intermediate Goods Production, Continued

- Newly created matches become productive only in the next period (Krause and Lubik, 2007).

- For an individual firm, the inflow of new hires in $t+1$ is therefore $q_t \upsilon_t$, where υ_t is the number of vacancies posted by the firm in period t.

- Firms and workers can separate exogenously with probability $\lambda \in (0,1)$.

- $\Rightarrow$ law of motion of employment, l_t (those who are working at time t), in a given firm:

$$l_t = (1-\lambda) l_{t-1} + q_{t-1} \upsilon_{t-1}.$$

Intermediate Goods Production, Continued

- The representative intermediate firm produces $y_t^I = Z_t l_t h_t$, where Z_t is exogenous aggregate productivity:

$$\begin{bmatrix} \log Z_t \\ \log Z_t^* \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} \log Z_{t-1} \\ \log Z_{t-1}^* \end{bmatrix} + \begin{bmatrix} \epsilon_t \\ \epsilon_t^* \end{bmatrix}.$$

- Firms faces a quadratic cost of adjusting the hourly nominal wage rate, w_t (Arsenau and Chugh, 2008).

- For each worker, the cost of changing the nominal wage between period t and $t+1$ (in units of consumption) is $\vartheta \pi_{w,t}^2/2$, $\vartheta \geq 0$, where $\pi_{w,t} \equiv (w_t/w_{t-1}) - 1$.

Intermediate Goods Production, Continued

- Intermediate producers sell to final producers at price φ_t in units of consumption.

- They choose the number of vacancies, υ_t, and employment, l_t, to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{u_{C,t}}{u_{C,0}} \left(\varphi_t Z_t l_t h_t - \frac{w_t}{P_t} l_t h_t - \kappa \upsilon_t - \frac{\vartheta}{2} \pi_{w,t}^2 l_t \right).$$

  - Domestic households are assumed to own Home firms.

- F.o.c.'s for vacancies and employment $\Rightarrow$ job creation equation:

$$\frac{\kappa}{q_t} = E_t \left\{ \beta_{t,t+1} \left[(1-\lambda) \frac{\kappa}{q_{t+1}} + \varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2} \pi_{w,t+1}^2 \right] \right\}, \quad \beta_{t,t+1} \equiv \beta u_{C,t+1} / u_{C,t}.$$

  - At the optimum, the vacancy creation cost per current match is equal to the expected discounted value of the vacancy creation cost per future match (further discounted by the probability of current match survival $1-\lambda$), plus the profits from the time-t match.

  - Profits from the match take into account the future marginal revenue product from the match and its wage cost, including future nominal wage adjustment costs.

Intermediate Goods Production, Continued

Wage Determination

- w_t solves individual Nash bargaining process, dividing match surplus between workers and firms.
  - Due to the presence of nominal rigidities, we depart from the standard Nash bargaining convention by assuming that bargaining occurs over nominal rather than real wage (Arseneau and Chugh, 2008; Gertler, Trigari, and Sala, 2008; Thomas, 2008).

Intermediate Goods Production, Continued

- $J_t =$ real value of existing, productive match for a producer:

$$J_t = \varphi_t Z_t h_t - \frac{w_t}{P_t} h_t - \frac{\vartheta}{2} \pi_{w,t}^2 + E_t \beta_{t,t+1} (1 - \lambda) J_{t+1}.$$

  – $J_t =$ per period marginal value product of match, $\varphi_t Z_t h_t$, net of wage bill and costs to adjust wages, plus expected discounted continuation value.

Intermediate Goods Production, Continued

- Let $W_t =$ worker's asset value of being matched, $U_{u,t} =$ value of being unemployed $\Rightarrow$

$$W_t = \frac{w_t}{P_t} h_t + E_t \left\{ \beta_{t,t+1} \left[(1-\lambda) W_{t+1} + \lambda U_{u,t+1} \right] \right\}.$$

  – $W_t =$ real wage bill the worker receives plus expected future value of being matched to the firm.

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$$U_{u,t} = \frac{v(h_t)}{u_{C,t}} + b + E_t \left\{ \beta_{t,t+1} [(\iota_t W_{t+1} + (1-\iota_t) U_{u,t+1}] \right\}.$$

  – $(h_t)/u_{C,t} =$ utility gain from leisure in terms of consumption, $b =$ unemployment benefit from the government (financed with lump sum taxes), $\iota_t =$ probability of becoming employed at time t: $\iota_t \equiv M_t / U_t$.

Intermediate Goods Production, Continued

- $\Rightarrow$ worker's surplus $H_t \equiv W_t - U_{u,t}$:

$$H_t = \frac{w_t}{P_t} h_t - \left(\frac{v(h_t)}{u_{C,t}} + b \right) + (1 - \lambda - \iota_t) E_t \left(\beta_{t,t+1} H_{t+1} \right).$$

- Nash bargaining maximizes joint surplus $J_t^{\eta} H_t^{1-\eta}$ with respect to w_t, where $\eta \in (0,1)$ is the firm's bargaining power.

- F.o.c. implies sharing rule:

$$\eta_t H_t + (1 - \eta_t) J_t = 0, \quad \text{where} \quad \eta_t = \frac{\eta}{\eta - (1-\eta) \left(\frac{\partial H_t}{\partial w_t} / \frac{\partial J_t}{\partial w_t} \right)}.$$

  - As in Gertler and Trigari (2009), bargaining shares are time-varying due to the presence of wage adjustment costs.

- Sharing rule $\Rightarrow$ bargained wage.

Intermediate Goods Production, Continued

- Hours per worker are determined by firms and workers in a privately efficient way, i.e., to maximize the joint surplus of their employment relation $\Rightarrow J_t + H_t$.

- $\Rightarrow v_{h,t}/u_{C,t} = \varphi_t Z_t$.
  - Hours are independent of the wage, precisely because they are chosen to maximize the joint surplus.

Final Goods Production

- In each consumption sector i, the representative, monopolistically competitive producer i produces the sectoral output bundle (or the bundle of product features) $Y_t(i)$, sold to consumers in Home and Foreign.

- Producer i is a multi-product firm that produces a set of differentiated product varieties (or features), indexed by ω and defined over a continuum Ω:

$$Y_t(i) = \left(\int_{\omega \in \Omega} y_t(\omega, i)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}}, \quad \theta > 1.$$

  - Note 1: Sectors (and sector-representative firms) are small relative to the overall size of the economy.
  - Note 2: Each product variety $y_t(\omega, i)$ is created and developed by the final producer i.

- Drop the index i to simplify notation (symmetry).

- The cost of the product bundle Y_t, denoted with P_t^y, is:

$$P_t^y = \left(\int_{\omega \in \Omega}^{\infty} p_t^y(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}},$$

where $p_t^y(\omega)$ is the nominal marginal cost of producing variety ω.

Final Goods Production, Continued

- The number of products (or product features) created and commercialized by each final producer is endogenous.

- At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers.

- To create a new product, the final producer needs to undertake a sunk investment, $f_{e,t}$, in units of intermediate input.
  - Product creation requires each final producer to creates a new plant that will be producing the new variety.

Final Goods Production, Continued

- Plants produce with different technologies indexed by relative productivity z.
- To save notation, identify a variety with the corresponding plant productivity z, omitting ω.
- Upon product creation, the productivity level of the new plant z is drawn from a common distribution $G(z)$ with support on $[z_{\min}, \infty)$.
- Foreign plants draw productivity levels from an identical distribution.
- This relative productivity level remains fixed thereafter.
- Each plant uses intermediate input to produce its differentiated product variety, with real marginal cost:

$$\varphi_{z,t} \equiv \frac{p_t^y(z)}{P_t} = \frac{\varphi_t}{z}.$$

Final Goods Production, Continued

- At time t, each final Home producer commercializes $N_{d,t}$ varieties and creates $N_{e,t}$ new products that will be available for sale at time $t+1$.

- New and incumbent plants can be hit by a “death” shock with probability $\delta \in (0,1)$ at the end of each period.

- $\Rightarrow$ The law of motion for the stock of producing plants is

$$N_{d,t+1} = (1-\delta)(N_{d,t} + N_{e,t}).$$

The Export Decision

- When serving the Foreign market, each final producer faces per-unit iceberg trade costs, $\tau_t > 1$, and fixed export costs, $f_{x,t}$.
- Fixed export costs are denominated in units of intermediate input and paid for each exported product.
- Thus, the total fixed cost is $\overline{f}_{x,t} = N_{x,t} f_{x,t}$, where $N_{x,t}$ denotes the number of product varieties (or features) exported to Foreign.
- Absent fixed export costs, each producer would find it optimal to sell all its product varieties in Home and Foreign.
- Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above a cutoff level $z_{x,t}$) are exported.
- $z_{x,t}$ is the lowest level of plant productivity such that the profit from exporting is positive (determined below)

Productivity Averages and Cost Minimization

- Define two special "average" productivity levels (weighted by relative output shares): an average $\tilde{z}_d$ for all producing plants and an average $\tilde{z}_{x,t}$ for all plants that export:

$$\tilde{z}_d = \left[\int_{z_{\min}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}, \qquad \tilde{z}_{x,t} = \left[\frac{1}{1-G(z_{x,t})}\right]\left[\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}.$$

- Assume that $G(\cdot)$ is Pareto with shape parameter $k > \theta - 1 \Rightarrow$

$$\tilde{z}_d = \alpha^{\frac{1}{\theta-1}} z_{\min} \quad \text{and} \quad \tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}, \quad \text{where} \quad \alpha = k/\left[k - (\theta - 1)\right].$$

- The share of exporting plants is given by:

$$N_{x,t} \equiv \left[1 - G(z_{x,t})\right] N_{d,t} = \left(\frac{z_{\min}}{\tilde{z}_{x,t}}\right)^{-k} \alpha^{\frac{k}{\theta-1}} N_{d,t}. \qquad (1)$$

Productivity Averages and Cost Minimization, Continued

- Define the output bundles for domestic and export sale and associated unit costs:

$$Y_{d,t} = \left[\int_{z_{\min}}^{\infty} y_{d,t}(z)^{\frac{\theta-1}{\theta}} dG(z) \right]^{\frac{\theta}{\theta-1}}, \qquad Y_{x,t} = \left[\int_{z_{x,t}}^{\infty} y_{x,t}(z)^{\frac{\theta-1}{\theta}} dG(z) \right]^{\frac{\theta}{\theta-1}},$$

$$P^y_{d,t} = \left[\int_{z_{\min}}^{\infty} p^y_t(z)^{1-\theta} dG(z) \right]^{\frac{1}{1-\theta}}, \qquad P^y_{x,t} = \left[\int_{z_{x,t}}^{\infty} p^y_t(z)^{\frac{\theta-1}{\theta}} dG(z) \right]^{\frac{1}{1-\theta}}.$$

- The real costs of producing the bundles $Y_{d,t}$ and $Y_{x,t}$ can then be expressed as:

$$\frac{P^y_{d,t}}{P_t} = N_{d,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_d}, \qquad \frac{P^y_{x,t}}{P_t} = N_{x,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_{x,t}}. \tag{2}$$

Productivity Averages and Cost Minimization, Continued

- The total present discounted cost facing the final producer is thus:

$$E_t \left\{ \sum_{s=t}^{\infty} \beta_{t,t+s} \left[\frac{P_{d,s}^y}{P_s} Y_{d,s} + \tau_s \frac{P_{x,s}^y}{P_s} Y_{x,s} + \left(\frac{N_{s+1}}{1-\delta} - N_s \right) f_{e,s} \varphi_s + N_{x,s} f_{x,s} \varphi_s \right] \right\}.$$

where $\beta_{t,t+s} = \beta(u_{C,t+s}/u_{C,t})$ is the stochastic discount factor.

- The producer determines $N_{d,t+1}$ and the productivity cutoff $z_{x,t}$ to minimize this expression subject to (1), (2), and $\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}$.

Export Cutoff Determination

- The first-order condition with respect to $z_{x,t}$ yields:

$$\frac{P^y_{x,t}}{P_t} Y_{x,t} \tau_t = \frac{(\theta-1)k}{[k-(\theta-1)]} f_{x,t} N_{x,t} \varphi_t .$$

  - The marginal revenue from adding a variety with productivity $z_{x,t}$ to the export bundle has to be equal to the fixed cost.
  - Varieties produced by plants with productivity below $z_{x,t}$ are distributed only in the domestic market.
  - The composition of the traded bundle is endogenous and the set of exported products fluctuates over time with changes in the profitability of export.

Product Creation

- The first-order condition with respect to $N_{d,t+1}$ determines product creation:

$$\varphi_t f_{e,t} = E_t \left\{ (1-\delta)\,\beta_{t,t+1} \left[\begin{array}{c} \varphi_{t+1}\left(f_{e,t+1} - \frac{N_{x,t+1}}{N_{d,t+1}} f_{x,t+1}\right) \\ +\frac{1}{\theta-1}\left(\frac{P^y_{d,t+1}Y_{d,t+1}}{P_{t+1}N_{t+1}} + \frac{P^y_{x,t+1}Y_{x,t+1}}{P_{t+1}N_{t+1}}\tau_{t+1}\right) \end{array} \right] \right\}.$$

  – In equilibrium, the cost of producing an additional variety, $\varphi_t f_{e,t}$, must be equal to its expected benefit (expected savings on future sunk investment costs augmented by the marginal revenue from commercializing the variety, net of fixed export costs, if it is exported).

Price Setting

- Denote with $P_{d,t}$ the price of the product bundle $Y_{d,t}$ in Home currency and $P_{x,t}$ the price of the exported bundle $Y_{x,t}$ in Foreign currency.

- Each final producer faces the following domestic and foreign demand for its product bundles:

$$Y_{d,t} = \left(\frac{P_{d,t}}{P_t}\right)^{-\phi} Y_t^C, \qquad Y_{x,t} = \left(\frac{P_{x,t}}{P_t^*}\right)^{-\phi} Y_t^{C*},$$

  where Y_t^C and Y_t^{C*} are aggregate demands of the consumption basket in Home and Foreign.

  – Aggregate demand in each country includes sources other than household consumption, but it takes the same form as the consumption basket, with the same elasticity of substitution $\phi > 1$ across sectoral bundles.

  – This ensures that the consumption price index for the consumption aggregator is also the price index for aggregate demand of the basket.

Price Setting, Continued

- Prices are sticky: Final producers must pay quadratic price adjustment costs when changing domestic and export prices (Rotemberg, 1982).

- Benchmark: producer currency pricing (PCP): Each final producer sets $P_{d,t}$ and the domestic currency price of the export bundle, $P^h_{x,t}$, letting the price in the foreign market be $P_{x,t} = \tau_t P^h_{x,t}/S_t$, where S_t is the nominal exchange rate.

- The nominal costs of adjusting domestic and export price are, respectively,

$$\Gamma_{d,t} \equiv \nu \pi^2_{d,t} P_{d,t} Y_{d,t}/2, \quad \text{and} \quad \Gamma^h_{x,t} \equiv \nu \pi^{h^2}_{x,t} P^h_{x,t} Y_{x,t}/2, \quad \nu \geq 0, \quad \pi_{d,t} \equiv (P_{d,t}/P_{d,t-1}) - 1$$

determines the size of the adjustment cost, $\pi_{d,t} = (P_{d,t}/P_{d,t-1}) - 1$ and $\pi^h_{x,t} = (P^h_{x,t}/P^h_{x,t-1}) - 1$.

Price Setting, Continued

- Absent fixed export costs, the producer would set a single price $P_{d,t}$ and the law of one price (adjusted for the presence of trade costs) would determine the export price as $P_{x,t} = \tau_t P_{x,t} = \tau_t P_{d,t}/S_t$.

- With fixed export costs, however, the composition of domestic and export bundles is different, and the marginal costs of producing these bundles are not equal.

- Therefore, final producers choose two different prices for the Home and Foreign markets even under PCP.

Price Setting, Continued

- Optimal price setting yields:

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{(\phi - 1)\,\Xi_{d,t}} \left(\frac{P^y_{d,t}}{P_t} \right), \tag{3}$$

where:

$$\Xi_{d,t} \equiv \left(1 - \frac{\nu}{2}\pi^2_{d,t}\right)\nu\left(\pi_{d,t} + 1\right)\pi_{d,t} - \frac{\nu}{(\phi - 1)} E_t \left[\beta_{t,t+1}\left(\pi_{d,t+1} + 1\right)\pi_{d,t+1}\frac{Y_{d,t+1}}{Y_{d,t}} \right],$$

and:

$$\frac{P_{x,t}}{P^*_t} = \frac{\phi}{(\phi - 1)\,\Xi^h_{x,t}} \left(\frac{\tau_t P^y_{x,t}}{Q_t P_t} \right), \tag{4}$$

where $Q_t \equiv SP^*_t/P_t$ is the consumption-based real exchange rate, and:

$$\Xi^h_{x,t} \equiv \left(1 - \frac{\nu}{2}\pi^{h^2}_{x,t}\right)\nu\left(\pi^h_{x,t} + 1\right)\pi^h_{x,t} - \frac{\nu}{(\phi - 1)} E_t \left[\beta_{t,t+1}\left(\pi^h_{x,t+1} + 1\right)\pi^h_{x,t+1}\frac{Y_{x,t+1}}{Y_{x,t}} \right].$$

  - Absent fixed export costs $z_{x,t} = z_{\min}$ and $\Xi_{x,t} = \Xi^h_{d,t}$.
  - Plant heterogeneity and fixed export costs imply that the law of one price does not hold for the exported bundles.

Price Setting, Continued

- To facilitate comparison with the original Ghironi-Melitz model, define the average price of a domestic variety, $\tilde{\rho}_{d,t} \equiv N_{d,t}^{\frac{1}{\theta-1}} (P_{d,t}/P_t)$ and the average price of an exported variety, $\tilde{\rho}_{x,t} \equiv N_{x,t}^{\frac{1}{\theta-1}} (P_{x,t}/P_t^*)$.

- Combining (2), (3), and (4), we have:

$$\tilde{\rho}_{d,t} = \mu_{d,t}\frac{\varphi_t}{\tilde{z}_d}, \qquad \tilde{\rho}_{x,t} = \mu_{x,t}\frac{\tau_t}{Q_t}\frac{\varphi_t}{\tilde{z}_{x,t}},$$

$$\text{where} \quad \mu_{d,t} \equiv \phi/\left((\phi-1)\,\Xi_{d,t}\right) \quad \text{and} \quad \mu_{x,t} \equiv \phi/\left((\phi-1)\,\Xi_{x,t}^h\right).$$

- These pricing equations would be identical to those in Ghironi-Melitz model absent time variation in markups due to sticky prices.

- For future purposes, define also the average output of domestic and exported varieties:

$$\tilde{y}_{d,t} \equiv \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^C, \qquad \tilde{y}_{x,t} = \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*}.$$

Household Budget Constraint

- The representative household can invest in non-contingent bonds that are traded domestically and internationally.
- International assets markets are incomplete.
- Home bonds, issued by Home households, are denominated in Home currency; Foreign bonds, issued by Foreign households, are denominated in Foreign currency.
- We introduce costs of adjusting bond holdings to pin down the steady-state net foreign asset position and ensure stationarity of the model (Turnovsky, 1985).
- The Home household's period budget constraint is:

$$\begin{aligned} & A_{t+1} + S_t A_{*,t+1} + \frac{\psi}{2} P_t \left(\frac{A_{t+1}}{P_t} \right)^2 + \frac{\psi}{2} S_t P_t^* \left(\frac{A_{*,t+1}}{P_t^*} \right)^2 + P_t C_t + T_t^g \\ = \; & (1+i_t) A_t + (1+i_t^*) A_{*,t} S_t + w_t L_t + P_t b(1-l_t) + T_t^A + T_t^i + T_t^f . \end{aligned}$$

  - $T_t^g =$ lump-sum tax that finances unemployment benefits, $T_t^A =$ lump-sum rebate of the costs of adjusting bond holdings, and $T_t^i =$ lump-sum rebate of profits from intermediate producers, $T_t^f =$ lump-sum rebate of profits from intermediate producers.

Household Intertemporal Decisions

- Let $a_{t+1} \equiv A_{t+1}/P_t$ and $a_{*,t+1} \equiv A_{*,t+1}/P_t^*$. $\Rightarrow$ The Euler equations for bond holdings are:

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

$$1 + \psi a_{*t+1} = (1 + i^*_{t+1}) E_t \left[\beta_{t,t+1} \frac{Q_{t+1}}{Q_t \left(1 + \pi^*_{C,t+1} \right)} \right],$$

where $\pi_{C,t} \equiv (P_t/P_{t-1}) - 1$ and $\pi^*_{C,t+1} \equiv \left(P_t^*/P^*_{t-1} \right) - 1$.

Net Foreign Assets

- Bonds are in zero net supply, which implies $a_{t+1} + a^*_{t+1} = 0$ and $a^*_{*,t+1} + a_{*,t+1} = 0$ in all periods.

- Home net foreign assets are determined by:

$$a_{t+1} + Q_t a_{*,t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + Q_t \frac{1+i^*_t}{1+\pi^*_{C,t}} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N^*_{x,t} \tilde{\rho}^*_{x,t} \tilde{y}^*_{x,t}.$$

- Defining $1 + r_t \equiv (1 + i_t) / (1 + \pi_{C,t})$, the change in net foreign assets between t and $t+1$ is determined by the current account:

$$(a_{t+1} - a_t) + Q_t (a_{*,t+1} - a_{*,t}) = CA_t \equiv r_t a_t + Q_t r^*_t a_{*,t} + TB_t,$$

where TB_t is the trade balance:

$$TB_t \equiv Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N^*_{x,t} \tilde{\rho}^*_{x,t} \tilde{y}^*_{x,t}.$$

Monetary Policy

- We compare the Ramsey-optimal, cooperative conduct of monetary policy to:
  - Historical central bank behavior under a flexible exchange rate, captured by a standard rule for interest rate setting in the spirit of Taylor (1993) for both central banks.
  - Optimized, inward-looking interest rate rules under a flexible exchange rate.
  - An exchange rate peg, in which a country sets its interest rate and the other pegs the exchange rate.
  - Non-cooperative, unrestricted optimal policy.

Data-Consistent Variables

- Variables measured in units of consumption do not have a direct counterpart in the data, i.e., they are not data-consistent (Ghironi and Melitz, 2005).

- Construct average price index $\tilde{P}_t$ as:

$$\tilde{P}_t = N_t^{\frac{1}{\phi-1}} P_t,$$

  where P_t is the welfare-based price index and $N_t \equiv N_{d,t} + N_{x,t}^*$.

- $\tilde{P}_t$ closer to the actual CPI data than P_t.

- Given any variable X_t in units of consumption, its data-consistent counterpart is:

$$X_{R,t} \equiv \frac{X_t P_t}{\tilde{P}_t} = \frac{X_t}{\Omega_t^{\frac{1}{\phi-1}}}.$$

Historical Monetary Policy

- Since we calibrate the model to match features of the U.S. post-Bretton Woods, we consider a flexible exchange rate regime in which each country's central bank sets its interest rate to respond to data-consistent CPI inflation and GDP gap relative to the equilibrium with flexible prices and wages.

- For the home country:

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

  where $\tilde{\pi}_{C,t}$ is the data-consistent CPI inflation and $\tilde{Y}_{g,t}$ is the data-consistent output gap.

Ramsey-Optimal, Cooperative Monetary Policy

- The world Ramsey authority maximizes aggregate welfare,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{2} \left[u(C_t) - l_t v(h_t) \right] + \frac{1}{2} \left[u(C_t^*) - l_t^* v(h_t^*) \right] \right\},$$

under the constraints of the competitive economy.

- Following the literature, we write the original non-stationary Ramsey problem in a recursive stationary form by enlarging the planner's state space with additional (pseudo) co-state variables.

- These co-state variables track the value to the planner of committing to the pre-announced policy plan along the dynamics.

Inefficiency Wedges

- The Ramsey planner uses its policy instruments (the Home and Foreign interest rates) to address the consequences of a set of distortions that exist in the market economy.

- To understand these distortions and the tradeoffs they create for policy, compare the equilibrium conditions of the market economy to those implied by the solution to a first-best, optimal planning problem.

- The decentralized economy features ten sources of distortion (italics below), affecting four margins of adjustment and the resource constraint for consumption output.

Inefficiency Wedges, Continued

- **Product Creation Margin:** *Time variation* and *lack of synchronization* in domestic and export markups, $\Upsilon_{\mu_{d,t}} \equiv (\mu_{d,t-1}/\mu_{d,t}) - 1$ and $\Upsilon_{\mu_{x,t}} \equiv (\mu_{d,t}/\mu_{x,t}) - 1$, distort product creation.

- **Job creation margin:** *Monopoly power* in the final sector distorts job creation, $\Upsilon_{\varphi,t} \equiv 1/\mu_{d,t}$. *Failure of the Hosios condition* is an additional distortion in this margin, measured by $\Upsilon_{\eta,t} \equiv \eta_t - \varepsilon$. *Sticky wages* distort job creation also by affecting the outside option of firms: $\Upsilon_{\pi_w,t} \equiv \vartheta\pi^2_{w,t}/2$. Finally, *unemployment benefits* increase the workers' outside option above its efficient level: $\Upsilon_{b,t} \equiv b$.

- **Labor supply margin:** With endogenous labor supply, monopoly power in product markets, $\Upsilon_{\varphi,t} \equiv \left(1/\mu_{d,t}\right) - 1$, induces a *misalignment of relative prices* between consumption goods and leisure. The associated wedge is time-varying for the presence of sticky prices.

Inefficiency Wedges, Continued

- **Cross-country risk sharing margin:** *Incomplete markets* imply inefficient risk sharing between Home and Foreign households, $\Upsilon_{Q,t} \equiv \left(u^*_{C,t}/u_{C,t}\right) - Q_t$. The departure of relative consumption from the perfect risk sharing outcome is also affected by the *costs of adjusting bond holdings* ($\Upsilon_{a,t} \equiv \psi a_{t+1} + \psi a_{*,t+1}$ and its Foreign mirror image).

- **Consumption resource constraint:** *Sticky prices and wages* imply diversion of resources from consumption and creation of new product lines and vacancies, with the distortions $\Upsilon_{\pi_w,t} \equiv \vartheta \pi^2_{w,t}/2$, $\Upsilon_{\pi_d,t} \equiv \nu \pi^2_{d,t}/2$ and $\Upsilon_{\pi_x,t} \equiv \nu \pi^2_{x,t}/2$.

- The market allocation is efficient only if all the distortions and associated inefficiency wedges are zero at all points in time.

- In the second-best environment of our paper, the Ramsey world central bank optimally uses its leverage on the world economy through the sticky-price and sticky-wage distortions, trading off their costs against the possibility of addressing the distortions that characterize the market economy under flexible wages and prices.

TABLE 3: DISTORTIONS

$\Upsilon_{\mu_{d,t}} \equiv \frac{\mu_{d,t}}{\mu_{d,t-1}} - 1$	time varying domestic markups, product creation
$\Upsilon_{\mu_{x,t}} \equiv \frac{\mu_{x,t}}{\mu_{d,t}} - 1$	time varying export markups, product creation
$\Upsilon_{\varphi,t} \equiv \frac{1}{\mu_{d,t}} - 1$	monopoly power, job creation and labor supply
$\Upsilon_{\eta,t} \equiv \eta_t - \varepsilon$	failure of the Hosios condition*, job creation
$\Upsilon_{b,t} \equiv b$	unemployment benefits, job creation
$\Upsilon_{Q,t} \equiv \frac{u^*_{c,t}}{u_{c,t}} - Q_t$	incomplete markets, risk sharing
$\Upsilon_{a,t} \equiv \psi a_{t+1} + \psi a_{*,t+1}$	cost of adjusting bond holdings, risk sharing
$\Upsilon_{\pi_w,t} \equiv \frac{\vartheta}{2}\pi^2_{w,t}$	wage adjustment costs, resource constraint and job creation
$\Upsilon_{\pi_{d,t}} \equiv \frac{\nu}{2}\pi^2_{d,t}$	domestic price adjustment costs
$\Upsilon_{\pi_{x,t}} \equiv \frac{\nu}{2}\pi^2_{x,t}$	export price adjustment costs

* From sticky wages and/or $\eta \neq \varepsilon$.

TABLE 4: CALIBRATION

	Parameter	Source/Target
Risk Aversion	$\gamma_C = 1$	Literature
Frisch elasticity	$1/\gamma_h = 0.4$	Literature
Discount Factor	$\beta = 0.99$	$r = 4\%$
Elasticity Matching Function	$\varepsilon = 0.4$	Literature
Firm Bargaining Power	$\eta = 0.4$	Literature
Home Production	$b = 0.54$	Literature
Exogenous separation	$\lambda = 0.10$	Literature
Vacancy Cost	$\kappa = 0.16$	$s = 60\%$
Matching Efficiency	$\chi = 0.68$	$q = 70\%$
Elasticity of Substitution	$\theta = 3.8$	Literature
Plant Exit	$\delta = 0.026$	$\frac{JD^{EXIT}}{JD} = 40\%$
Pareto Shape	$k = 3.4$	Literature
Pareto Support	$z_{\min} = 1$	Literature
Sunk Entry Cost	$f_e = 0.69$	Literature
Fixed Export Costs	$f_x = 0.005$	$(N_x/N) = 21\%$
Iceberg Trade Costs	$\tau = 1.75$	$(I + X)/Y = 10\%$
Rotemberg Wage Adj. Cost	$\vartheta = 60$	$\frac{\sigma_l}{\sigma_{Y_R}} = 0.56$
Rotemberg Price Adj. Cost	$\nu = 80$	Literature
Taylor - Interest Rate Smoothing	$\varrho_i = 0.71$	Literature
Taylor - Inflation Parameter	$\varrho_\pi = 1.62$	Literature
Taylor - Output Gap Parameter	$\varrho_Y = 0.34$	Literature
Bond Adjustment Cost	$\psi = 0.0025$	Literature

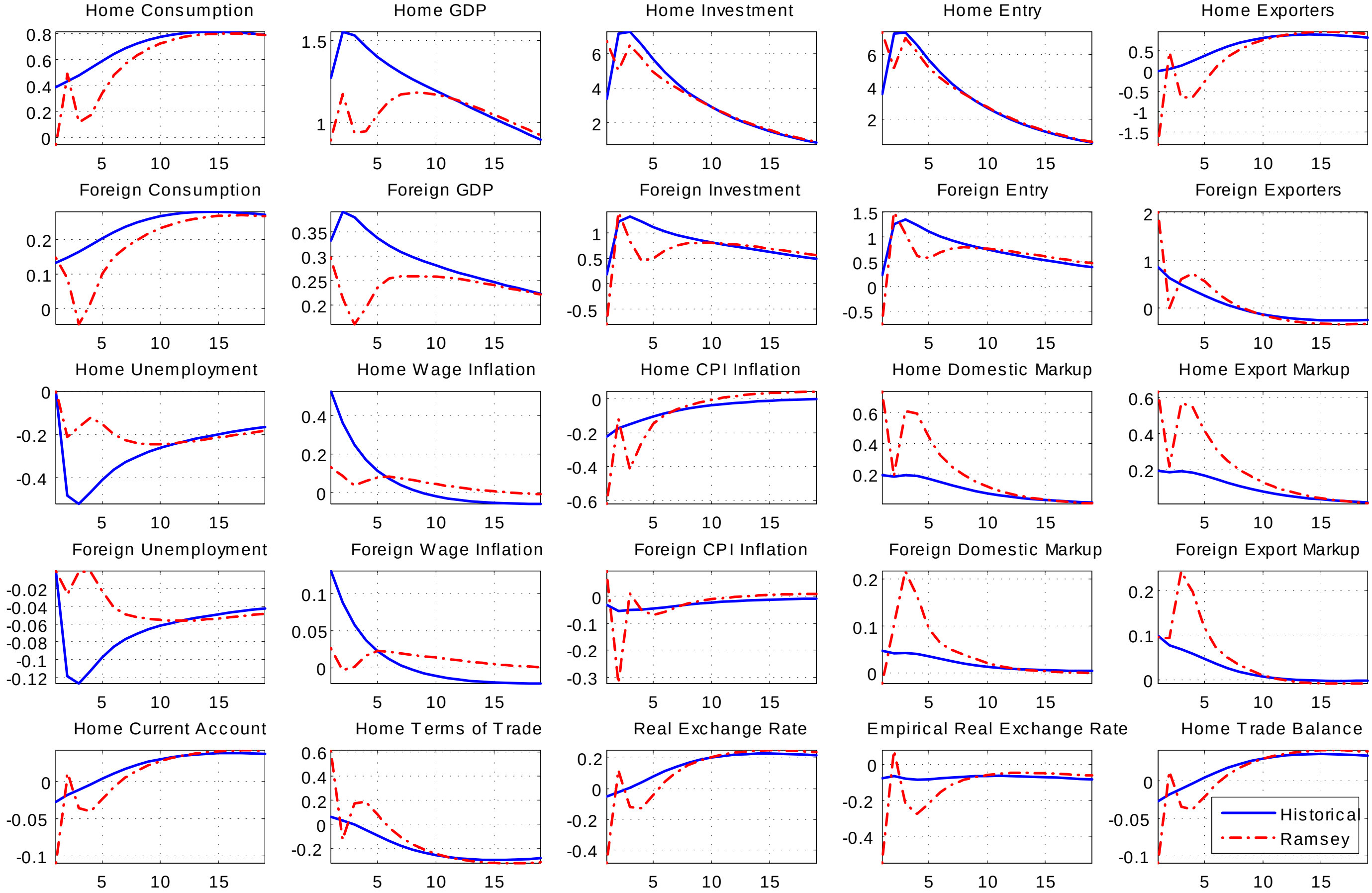

Figure 1: Home Productivity Shock, no trade linkages and producer currency pricing.

Variables are in percentage deviations from the steady state. Unemployment and inflation are in deviations from the steady state.

TABLE 5: BUSINESS CYCLE STATISTICS

Variable	$\sigma_{X_R^U}$		$\sigma_{X_R^U}/\sigma_{Y_R^U}$		1st Autocorr		$corr(X_{R,t}^U, Y_{R,t}^U)$	
Y_R	**1.71**	1.50	**1**	1	**0.83**	0.79	**1**	1
C_R	**1.11**	0.94	**0.64**	0.63	**0.70**	0.73	**0.67**	0.87
I_R	**5.48**	5.50	**3.20**	3.68	**0.89**	0.80	**0.87**	0.86
l	**0.97**	0.82	**0.56**	0.56	**0.88**	0.72	**0.79**	0.81
w_R	**0.91**	0.79	**0.52**	0.53	**0.91**	0.92	**0.56**	0.76
X_R	**5.46**	2.40	**3.18**	1.66	**0.67**	0.70	**0.18**	0.17
I_R	**4.35**	2.08	**2.54**	1.39	**0.32**	0.69	**0.70**	0.77
TB_R/Y_R	**0.25**	0.39	**0.14**	0.26	**0.43**	0.71	**-0.47**	-0.48
$corr(C_{R,t}, C_{R,t}^*)$	**0.44**	0.16						
$corr(Y_{R,t}, Y_{R,t}^*)$	**0.51**	0.26						

Bold fonts denote data moments, normal fonts denote model generated moments.

Optimal Monetary Policy with Weak Trade Linkages

Long Run

- Long-run inflation is always symmetric across countries.

- This follows from the steady-state Euler equations of households, which imply:

$$1 + \pi_C = \beta(1 + i) = 1 + \pi_C^*.$$

- Moreover, $\pi_C = \pi_d = \pi_x = \pi_w$.

- To understand the incentives that shape the optimal policy in the long run, notice that a symmetric long-run equilibrium with constant endogenous variables eliminates some distortions:

  - Constant, synchronized markups remove the markup variation and misalignment distortions from the product creation margin ($\Upsilon_{\mu_d} = \Upsilon_{\mu_x} = 0$).

  - Symmetry across countries removes the risk-sharing distortion of incomplete markets ($\Upsilon_Q = 0$), and constant, zero net foreign assets eliminate the effect of asset adjustment costs ($\Upsilon_a = 0$).

Optimal Monetary Policy with Weak Trade Linkages, Continued

Long Run, Continued

- The optimal long-run target for net inflation with low trade is 1.4 percent.

- **Intuition:** All the remaining steady-state distortions but the costs of wage and price adjustment require lower markups.
  - Firms' monopoly power in the downstream sector and positive unemployment benefits imply suboptimally low job-creation.
  - Since $\pi_C = \pi_w$, positive inflation raises the firms' bargaining power η, favoring vacancy posting by firms.

- However, the Ramsey authority must trade the beneficial welfare effects of reducing these distortions against the costs of non-zero inflation implied by allocating resources to wage and price changes and by the departure from the Hosios condition (since $\eta > \varepsilon$).

- Compared to the zero inflation outcome, the Ramsey authority reduces the inefficiency wedge in job creation.

- Welfare gains from Ramsey-optimal policy amount to 0.34 percent of annualized steady-state consumption.

TABLE 6: TRADE INTEGRATION – NON STOCHASTIC STEADY STATE

	Ramsey Gain	Ramsey Inflation
$\frac{Trade}{GDP} = 0.1$	0.34%	1.40%
$\frac{Trade}{GDP} = 0.2$	0.22%	1.20%
$\frac{Trade}{GDP} = 0.35$	0.16%	1.05%

Optimal Monetary Policy with Weak Trade Linkages

Business Cycle

- Relative to the historical rule (a policy of near producer price stability, defined as zero deviation of average domestic producer price inflation from its long-run level), the Ramsey authority generates a much smaller increase in wage inflation and a larger departure from price stability (disinflation).

- As in steady state, there is a tension between the beneficial effects of manipulating inflation and its costs.

- Moreover, there is a tradeoff between stabilizing inflation in consumption goods prices (which contributes to stabilizing domestic markups) and wage inflation (which stabilizes unemployment).

- Finally, there is a tension between stabilizing domestic markups, $\mu_{d,t}$, and export markups, $\mu_{x,t}$.

Optimal Monetary Policy with Weak Trade Linkages, Continued

Business Cycle, Continued

- Price stability is suboptimal because wage inflation is too volatile, and markup stabilization correspondingly too strong, under this policy.

- Historical Fed behavior result in positive employment comovement across countries.

- In contrast, the Ramsey authority pushes unemployment rates in opposite directions by engineering wage disinflation rather than inflation in the Foreign country.

- This results in higher unemployment in the relatively less productive economy.

- By implementing the Ramsey-optimal policy the welfare cost of business cycles falls by approximately 20 percent:
  - Optimal departures from price stability lower the cost of business cycles from 1.02 percent of steady-state consumption under the historical policy to 0.82 percent.

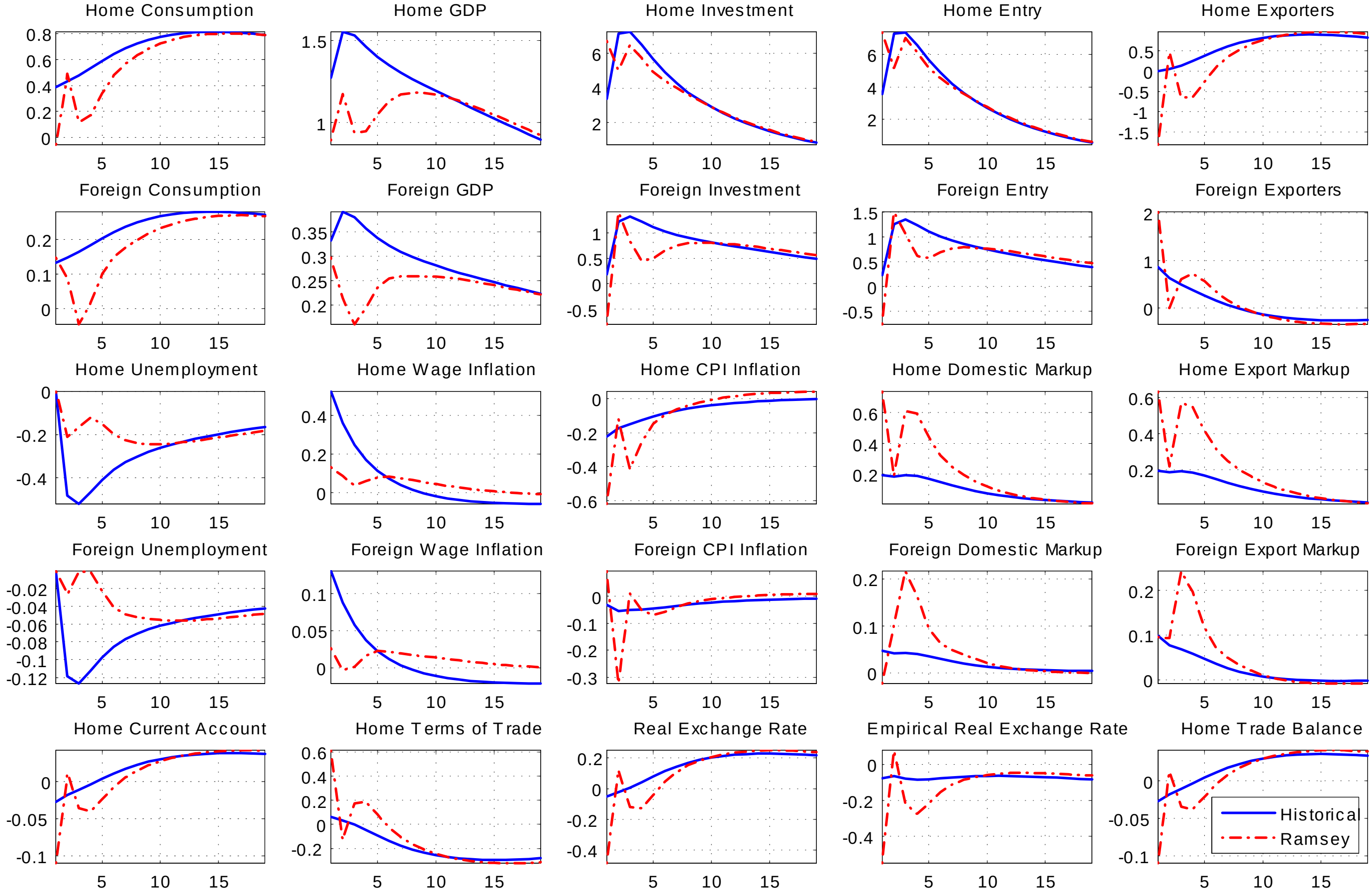

Figure 1: Home Productivity Shock, no trade linkages and producer currency pricing.

Variables are in percentage deviations from the steady state. Unemployment and inflation are in deviations from the steady state.

Optimal Monetary Policy with Weak Trade Linkages

Optimal Inward-Looking Rules

- Assume

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i)\,(1 + \tilde{\pi}_{d,t})^{\varrho_{\pi_d}}\,(1 + \tilde{\pi}_{w,t})^{\varrho_{\pi_w}} \left(Y^g_{R,t} \right)^{\varrho_Y} \right]^{1-\varrho_i}$$

  and similarly abroad, and optimize over response coefficients.

- Optimal responses: $\varrho_i = .60$, $\varrho_Y = 0$, $\varrho_{\pi_d} = 1.45$, and $\varrho_{\pi_w} = 3.75$.

- The welfare loss implied by the optimal interest rules relative to the Ramsey allocation is less than 1 percent (corresponding to 0.008 percent of steady state consumption).

- **Bottom line:** When trade linkages are weak, the Ramsey-optimal policy is well approximated by an inward-looking interest rate rule.

Optimal Monetary Policy and Trade Integration

Long Run

- Following reduction of trade barriers, the relative more productive non-exporting plants begin to export and the market share of domestic plants shrink due to increased foreign competition.

- Define a weighted productivity average $\tilde{z}$ that reflects the combined market shares of all Home firms and the output shrinkage linked to exporting:

$$\tilde{z} = \left\{ \left[\tilde{z}_d^{\theta-1} + \left(\frac{\tilde{z}_x}{\tau} \right)^{\theta-1} \frac{N_x}{N_d} \right] \right\}^{\frac{1}{\theta-1}} .$$

- Even if the average productivity of exporting plants, $\tilde{z}_x$, falls after trade integration, the gain in market shares of existing and new exporting plants is strong enough to guarantee that the average productivity $\tilde{z}$ increases.

- This has implications for monetary policy.

Optimal Monetary Policy and Trade Integration, Continued

Long Run, Continued

- Focus on the consequences of trade integration for steady-state inefficiency wedges under a long-run zero net inflation, $\pi_C = 0 = \Upsilon_{\pi_d} = \Upsilon_{\pi_x} = \Upsilon_{\pi_w}$.

- First, markups are constant and equal to one in steady state, and so $\Upsilon_{\mu_d} = \Upsilon_{\mu_x} = 0$.

- Moreover, the Hosios condition implied by our calibration ensures that $\eta = \varepsilon$ and $\Upsilon_\eta = \Upsilon_{\pi_w} = 0$.

- Finally, full symmetry across countries ensures that $\Upsilon_Q = 0$.

- Two distortions remain: the monopoly power distortion on job creation, $\Upsilon_\varphi = (1/\mu_d) - 1$, and non-zero unemployment benefits, leaving Υ_b unaffected.

Optimal Monetary Policy and Trade Integration, Continued

Long Run, Continued

- The effects of trade integration on welfare operates by indirectly reducing the welfare losses induced by Υ_{φ} and Υ_{b}.

- More precisely, trade integration raises average productivity and dampens the negative consequences of firms' monopoly power and distortionary unemployment benefits.

- To see this, let $\varkappa = q/\iota$ be labor market tightness.

- Since $U = \lambda / \left(\lambda + \varkappa^{\varepsilon}\right)$, the effect of trade integration on unemployment is summarized by the response of $\varkappa$ to changes in trade costs.

Optimal Monetary Policy and Trade Integration, Continued

Long Run, Continued

- Labor market tightness is an increasing function of the marginal revenue from a match, φ, i.e. $d\varkappa/d\varphi > 0$.

- Moreover, $\varphi = (1/\mu_d)\, N_d^{\frac{1}{\theta-1}} \tilde{z}$.

- Thus, the marginal revenue of a match and labor market tightness depend positively on the number of domestic varieties available to consumers, N_d, and the average productivity of firms $\tilde{z}$.

- Trade openness always decreases N_d but increases $\tilde{z}$.

Optimal Monetary Policy and Trade Integration, Continued

Long Run, Continued

- For any realistic parametrization of the model, the productivity effects dominate, implying that $\partial\varkappa/\partial\varphi > 0$.

- Thus, our model features a negative link between trade and unemployment, given that $\partial U/\partial\varkappa = -\partial\varkappa/\partial\varphi < 0$.
  - The increase in $\tilde{z}$ makes workers on average more productive, increasing the average marginal revenue of a match, and pushing employment toward its efficient level (Cacciatore, 2010, and Felbermayr, Prat, and Schmerer, 2011).

- Consistent with this, stronger trade lowers steady-state optimal inflation, which becomes 1 percent when trade integration reaches its maximum.

- Trade-induced productivity gains make price stability relatively more desirable since they reduce the need to resort to positive inflation to correct steady-state distortions.

Business Cycle

- Benigno and Benigno (2003): No gain from coordinating policies (flexible exchange rates and domestic price stability are optimal) if shocks are perfectly correlated across countries.

- Increased trade integration results in stronger business cycle comovement in our model.

- Fluctuations triggered by country-specific shocks become more global, resulting in an “endogenous” Benigno-Benigno result:

  - Contrary to the conventional argument, appropriately designed, inward-looking interest rate rules can still replicate the constrained efficient allocation and the need of cooperation remains muted.

  - However, historical (Fed) policy behavior implies inefficient fluctuations in cross-country demand, inducing larger welfare costs when trade linkages are strong.

    - Under a peg, welfare costs are larger for the center country under trade integration.

TABLE 7: TRADE INTEGRATION AND GDP COMOVEMENT

	$\Delta corr(Y_{R,t}, Y^*_{R,t})$—Producer Currency Price		
	$\frac{Trade}{GDP} = 0.1$	$\frac{Trade}{GDP} = 0.2$	$\frac{Trade}{GDP} = 0.35$
Historical Rule	0.36	0.45	0.49
Peg	0.05	0.19	0.27
Ramsey	0.07	0.29	0.43
Nash	0.28	0.35	0.48
	$corr(Y_{R,t}, Y^*_{R,t})$—Local Currency Price		
	$\frac{Trade}{GDP} = 0.1$	$\frac{Trade}{GDP} = 0.2$	$\frac{Trade}{GDP} = 0.35$
Historical Rule	0.33	0.42	0.47
Peg	0.05	0.20	0.27
Ramsey	0.36	0.53	0.62
Nash	0.28	0.36	0.42

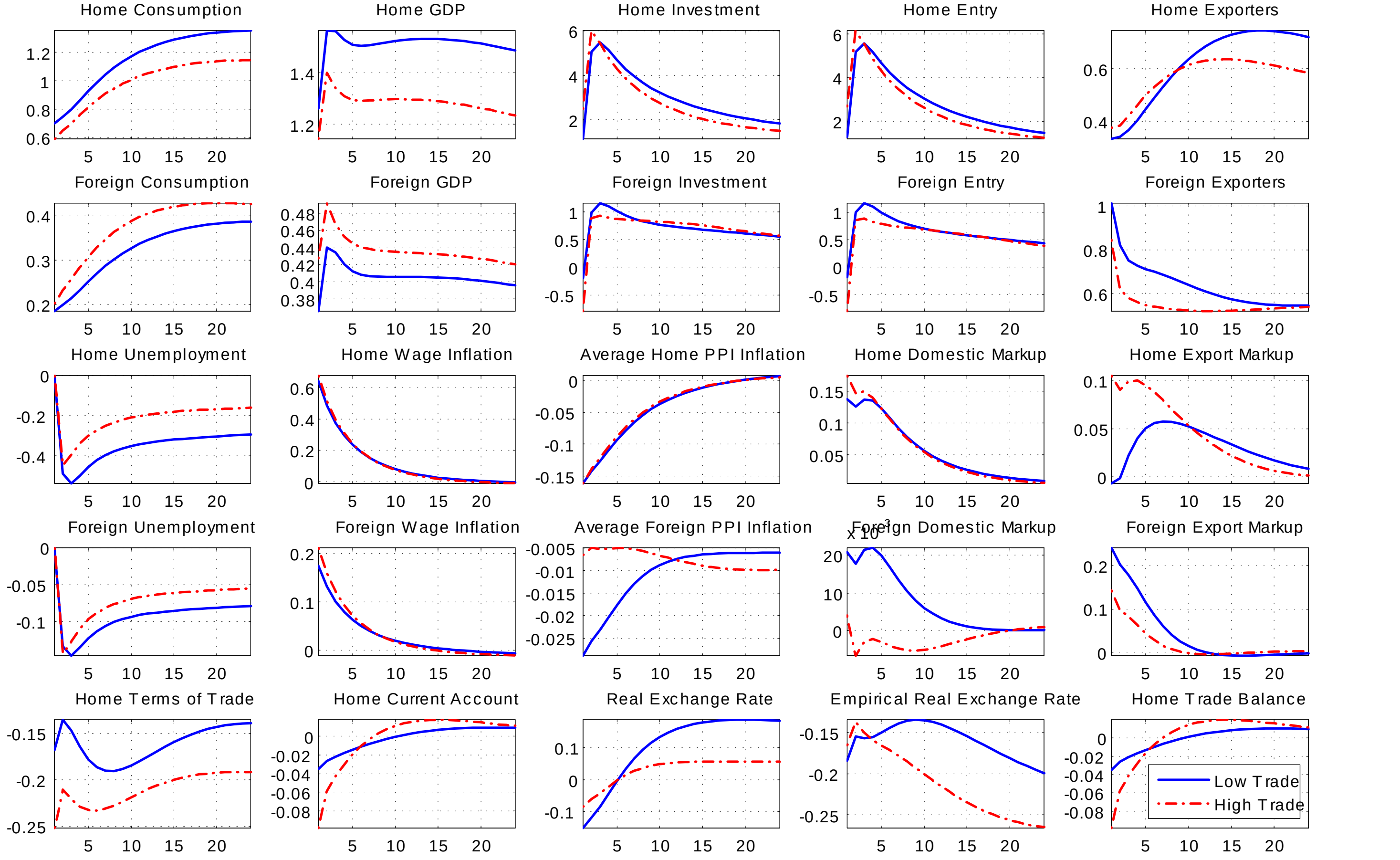

Figure 2: Home Productivity Shock, trade integration and producer currency pricing.

Variables are in percentage deviations from the steady state. Unemployment and inflation are in deviations from the steady state.

TABLE 8: TRADE INTEGRATION – NON STOCHASTIC STEADY STATE

	Relative Gain from Coordination —PCP*				
	Optimal Rule*	Historical Rule	Peg		Nash
			Leader	Follower	
$\frac{Trade}{GDP} = 0.1$	0.88%	18.62%	18.81%	43.45%	0.0001%
$\frac{Trade}{GDP} = 0.2$	3.13%	25.36%	26.90%	45.40%	0.001%
$\frac{Trade}{GDP} = 0.35$	3.15%	29.69%	32.31%	48.39%	0.09%

	Relative Gain from Coordination —LCP*				
	Optimal Rule**	Historical Rule	Peg		Nash
			Leader	Follower	
$\frac{Trade}{GDP} = 0.1$	2.17%	20.91%	20.89%	44.90%	0.10%
$\frac{Trade}{GDP} = 0.2$	2.66%	29.09%	29.49%	47.34%	0.90%
$\frac{Trade}{GDP} = 0.35$	3.16%	36.16%	37.00%	51.97%	2.42%

*Gains are the ratio of welfare costs of business cycle under the Ramsey-optimal policy and the alternative;

**The optimal rule is derived under weak trade linkages (10%) and producer currency pricing (PCP); the rule is kept constant across trade regimes and under local currency pricing (LCP).

Robustness

- Local currency pricing: Results are similar to PCP.
- Unrestricted, optimal non-cooperative policy:
  - Each central bank chooses policy to maximize welfare of its representative household.
  - Following Benigno and Benigno (2006), each policymaker's strategy is specified in terms of each country's consumer price inflation rate, $\pi_{C,t}$, as a function of the sequence of shocks, taking as given the sequence of the other country's consumer price inflation rates (two-country, open-loop Nash equilibrium).
  - In a Nash equilibrium, domestic policymakers have an incentive to manipulate their country's terms of trade, resulting into inefficient exchange rate volatility relative to the constrained efficient benchmark of policy cooperation.

Robustness, Continued

- – When trade linkages are weak, the welfare loss of non-cooperative monetary policy is very small, regardless of PCP vs. LCP.
  - Intuitively, weak trade linkages imply that each policymaker has little incentive to manipulate terms of trade.
  - Stronger trade linkages do not significantly change this conclusion.
  - Intuitively, increased synchronization reduces the incentives to manipulate terms of trade since fluctuations become endogenously more global.

Conclusions

- We re-examined classic questions on international monetary policy and trade integration in a DSGE model with micro-level trade dynamics and labor market frictions.

- Trade integration results in more benefit from cooperation relative to historical behavior, but optimized inward-looking policy rules can approximate the cooperative outcome.

- Our analysis highlights the endogenous increase in business cycle synchronization across countries generated by trade integration as a key reason why gains from cooperation may be small relative to optimal, inward-looking behavior.

- Missing? Financial imperfections and unconventional policy.

- Next in the agenda...

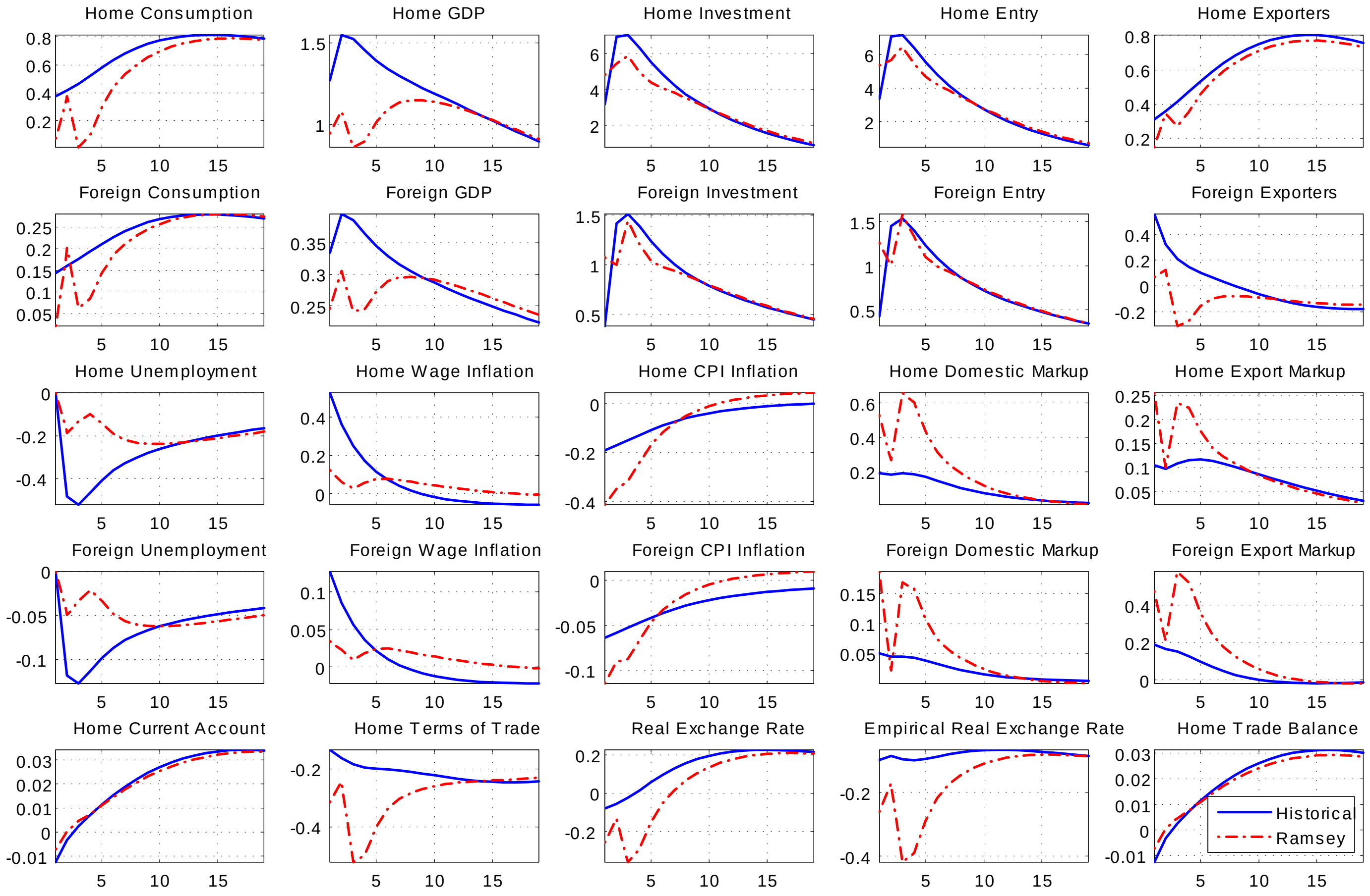

Figure 3: Home Productivity Shock, no trade linkages and local currency pricing.

Variables are in percentage deviations from the steady state. Unemployment and inflation are in deviations from the steady state.

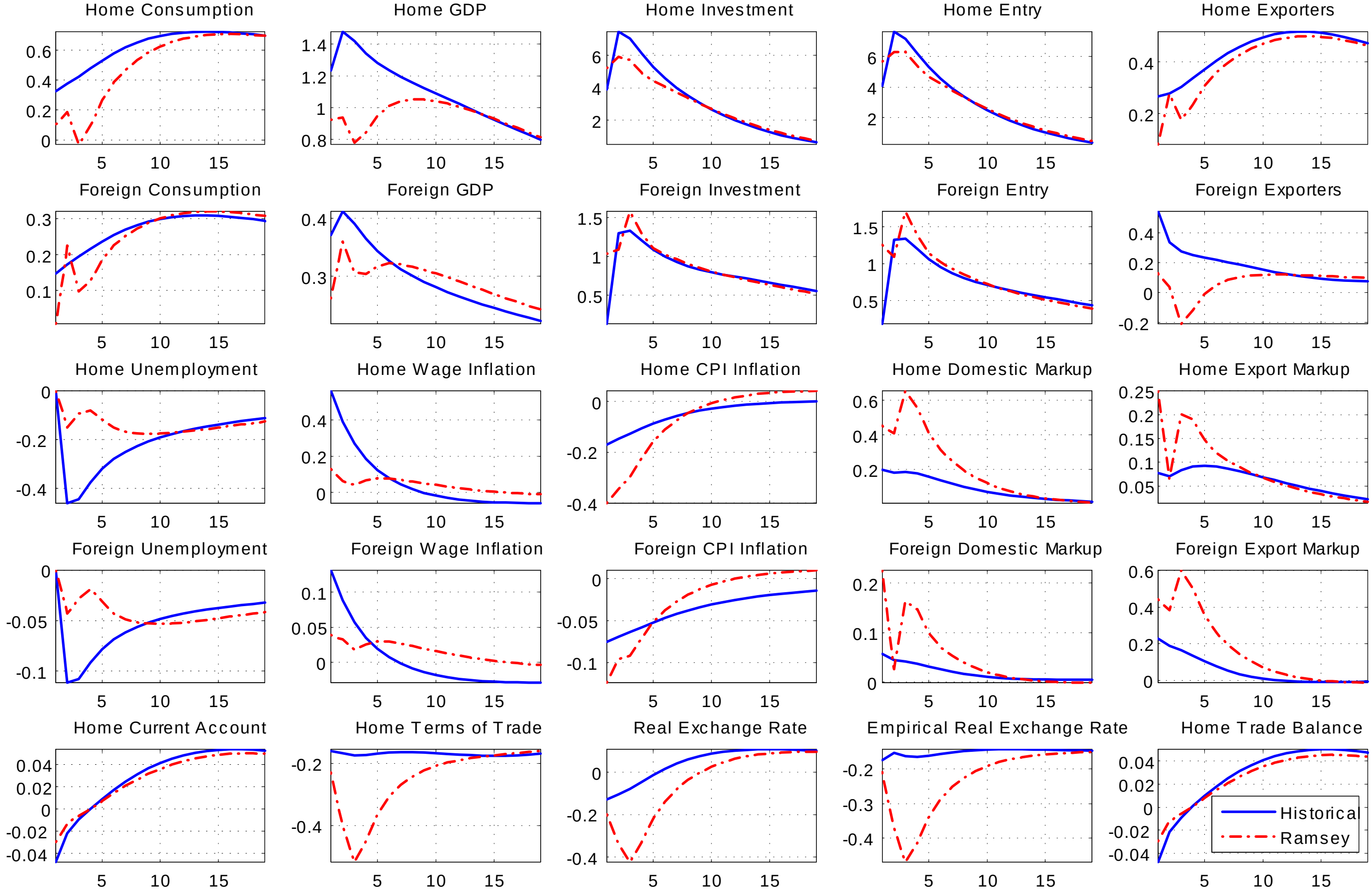

Figure 4: Home Productivity Shock, trade integration and local currency pricing.

Variables are in percentage deviations from the steady state. Unemployment and inflation are in deviations from the steady state.