Wesleyan Economic Working Papers

http://repec.wesleyan.edu/
N^o: 2012-001

Monetary Rules and Sectoral Unemployment in Open Economies

William D. Craighead

August 12, 2012

WESLEYAN UNIVERSITY

Department of Economics
Public Affairs Center
238 Church Street
Middletown, CT 06459-007

Tel: (860) 685-2340
Fax: (860) 685-2301
http://www.wesleyan.edu/econ

Monetary Rules and Sectoral Unemployment in Open Economies

William D. Craighead*
Wesleyan University

August 2012

Abstract

This paper incorporates a search-and-matching model of the labor market into a "New Open Economy Macroeconomics" framework. This allows for an examination of the behavior of tradable and nontradable sector unemployment rates under alternative monetary rules. An examination of dynamics in response to shocks to productivity, world prices and interest rates, and foreign demand suggests that monetary rules that respond to prices of domestic output rather than consumer prices may be better able to stabilize unemployment. (JEL: F4, E5)

*Assistant Professor, Department of Economics, Wesleyan University, 238 Church St, Middletown CT 06459 USA. E-mail: bcraighead@wesleyan.edu. Tel.: +1 860-685-5784. Fax: +1 860-685-2301.

Acknowledgements: I am grateful to seminar and conference participants at Clark University as well as the Eastern, Southern and Western Economic Association meetings and to Tomoya Suzuki, Ed Gamber and Judit Temesvary for helpful comments. Any errors are my own.

1 Introduction

This paper integrates labor market search into a small open economy model and examines the implications of alternative monetary policy rules for unemployment in the tradable and nontradable goods sectors. The inclusion of labor market search allows for an analysis of the behavior of unemployment rates, which are a key observable variable of concern to policymakers. This is in contrast to existing studies that evaluate monetary policy in terms of the utility of a representative agent or household, which is unobservable. Furthermore, the model described below allows for heterogeneity between tradable and nontradable goods sectors.

This paper builds on considerable literature analyzing monetary policy in open economy models with sticky prices and optimizing agents in the "New Open Economy Macroeconomics" tradition following Obstfeld and Rogoff (1995). This line of research represents an extension of the New Keynesian macroeconomic framework into an international setting. Entering an open economy setting raises several new issues for monetary policy, including whether policy should target consumer or producer (domestic) prices (which differ because of imported and exported goods). The results discussed below suggest that policy rules focused on producer prices may be superior in terms of stabilizing unemployment rates. This is complementary to Galí and Monacelli's (2005) conclusion that a policy rule responding to producer prices generates higher welfare than one based on stabilizing consumer prices or the exchange rate. The results are also consistent with Svensson's (2000) finding that strict consumer price targeting can generate higher volatility in other variables.

Dynamic general equilibrium macroeconomic models have generally determined the quantity of labor based on an optimizing labor-leisure choice by a representative household. One of the main criticisms of these models has been that they do not allow for involuntary unemployment. Incorporation of the Diamond-Mortensen-Pissarides (DMP) search and matching framework into has emerged as an approach to dealing with this issue. Merz (1995) and Andolfatto (1996) integrated labor market search into real business cycle (RBC) models. Several recent papers have combined labor market search and the New Keynesian macroeconomic framework. Walsh (2005) showed that the introduction of search and matching amplifies the real impact of an interest rate shock. Trigari (2009) estimates structural parameters of a New Keynesian model with labor market search. Thomas (2008) shows that if wages are sticky, the standard New Keynesian "divine coincidence" between inflation and output stabilization no longer holds. This tradeoff faced by the monetary authority between inflation and output stabilization is explored by Blanchard and Galí (2010).

This paper thus builds on the growing literature including search frictions in macroeconomic models models by extending the analysis to the open economy as well as contributing to the study of monetary policy in open economies by explicitly incorporating unemployment.[1]

2 Households

The model builds on that of Blanchard and Galí (2010, hereafter BG), by extending a version of it to an open economy with two intermediate goods production sectors. The "home" small open economy is represented by a household of unit measure, with members indexed by j, where a fraction s is allocated to the domestic tradable good sector (denoted D), and $1 - s$ is allocated to the nontradable good sector (N). The household receives utility from consumption

[1] Christiano, Trabandt and Walentin (2011) incorporate search into a rich open-economy DSGE model based on Sweden. However they do not investigate alternative monetary policies.

and disutility from labor; its utility function is

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \chi s \frac{\tilde{L}_{D,t}^{1+\phi}}{1+\phi} - \chi(1-s) \frac{\tilde{L}_{N,t}^{1+\phi}}{1+\phi} \right] \tag{1}$$

where $\tilde{L}_{D,t}$ and $\tilde{L}_{N,t}$ denote labor per worker in the D and N sectors. For each sector, total labor is the sum (integral) of labor supplied by the measure of the household membership in that sector;

$$L_{D,t} = \int_0^s \tilde{L}_{D,t}(j)dj = s\tilde{L}_{D,t} \qquad L_{N,t} = \int_s^1 \tilde{L}_{N,t}(j)dj = (1-s)\tilde{L}_{N,t}. \tag{2}$$

The consumption aggregate is a CES bundle of nontradable and tradable goods,

$$C_t = \left[(1-\omega)^{\frac{1}{\eta}} C_{N,t}^{\frac{\eta-1}{\eta}} + \omega^{\frac{1}{\eta}} C_{T,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3}$$

where η is the elasticity of substitution between tradable and nontradable goods and ω is a weighting parameter. Tradable goods consumption is comprised of both domestic and imported (M) goods,

$$C_{T,t} = \left[(1-\gamma)^{\frac{1}{\nu}} C_{M,t}^{\frac{\nu-1}{\nu}} + \gamma^{\frac{1}{\nu}} C_{D,t}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{4}$$

where ν is the elasticity of substitution between home and foreign tradables, and γ is a weighting parameter that represents "home bias" in consumption. The corresponding price indexes are given by

$$P_t = \left[(1-\omega) P_{N,t}^{1-\eta} + \omega P_{T,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{5}$$

and

$$P_{T,t} = \left[(1-\gamma) P_{M,t}^{1-\nu} + \gamma P_{D,t}^{1-\nu} \right]^{\frac{1}{1-\nu}}. \tag{6}$$

where and the price of imported goods is given by $P_M = eP^w$, which is the world price, P^w, converted into home currency, with the exchange rate, e, defined as the home price of foreign currency. Note P is the consumer price index.

Asset markets are incomplete; in addition to consumption goods the household can purchase nominal bonds that pay one unit of home and foreign (rest of world) currency, with B_t and B_t^F denoting beginning of period holdings of home and foreign bonds, respectively, and q_t and q_t^F denoting the prices of bonds paying off in the next period. The household earns labor income in both sectors (at wage rates w_D and w_N), receives income from bonds purchased in the previous period, and the profits of the home final goods firms, Π_N and Π_D. Intermediate goods production is competitive and hence there are no profits from intermediate gods firms. The household's budget constraint is therefore

$$P_t C_t + q_t B_{t+1} + e_t q_t^F B_{t+1}^F = w_{D,t} L_{D,t} + w_{N,t} L_{N,t} + B_t + e_t B_t^F + \Pi_{N,t} + \Pi_{D,t}. \quad (7)$$

3 Technology

The economy is assumed to have two types of firms in order to avoid the complication of interactions between wage- and price-setting problems.[2] Competitive intermediate goods firms hire labor and use it to produce goods. Final goods firms assemble the intermediate goods into differentiated products, and because competition among final goods is imperfect, have the power to set prices at a markup over cost.

The economy has a unit measure of intermediate goods firms, indexed by k, divided into s domestic tradable (D) firms and $1 - s$ nontradable producers (N). Separations occur at an exogenous rate, δ, and hires are given by H, so a

[2] This is a commonly-made assumption; Thomas (2011) examines the implications of relaxing it.

firm's labor evolves according to

$$L_{i,t}(k) = (1-\delta)L_{i,t-1}(k) + H_{i,t}(k) \qquad i = D, N. \tag{8}$$

Aggregate hiring in tradable and nontradable goods sectors are given by $H_{D,t} = \int_0^s H_t(k)dk$ and $H_{N,t} = \int_s^1 H_t(k)dk$, respectively. The number of people unemployed at the beginning of period t in each sector is

$$U_{D,t} = s - (1-\delta)L_{D,t-1} \tag{9}$$

$$U_{N,t} = (1-s) - (1-\delta)L_{N,t-1}. \tag{10}$$

Total hiring in each sector evolves according to

$$H_{i,t} = L_{i,t} - (1-\delta)L_{i,t-1} \qquad i = D, N. \tag{11}$$

After hiring occurs, the end-of-period unemployment rates are $u^r_{D,t} = \frac{1}{s}(U_{D,t} - H_{D,t})$ and $u^r_{N,t} = \frac{1}{1-s}(U_{N,t} - H_{N,t})$ in the tradable and nontradable sectors, respectively.

The ratio of hires to unemployed in each sector, which can be interpreted as both the job finding rate and as a measure of labor market tightness, is given by

$$x_{i,t} = \frac{H_{i,t}}{U_{i,t}} \qquad i = D, N. \tag{12}$$

Following a useful simplification of the DMP framework developed by BG, rather than paying a cost to post vacancies for an expected length of time that depends on labor market tightness, firms instead are assumed to face hiring costs which are increasing in labor market tightness. The marginal hiring cost is given by the function

$$G_{i,t} = z_{i,t}B\left(x_{i,t}\right)^{\alpha} \qquad i = D, N \tag{13}$$

where B is a constant. The hiring costs are taken as exogenous by individual firms and, for convenience, measured in units of aggregate output - i.e., the nominal hiring cost is PG.

The intermediate goods firms produce output using a linear combination of a productivity "shock" and labor, less hiring costs

$$Y_{i,t}(k) = z_{i,t}L_{i,t}(k) - \frac{P_t}{p^I_{i,t}}G_i H_{i,t}(k) \qquad i = D, N \tag{14}$$

where p^I is the intermediate goods price and $\frac{P}{p^I}GH$ is the real hiring cost expressed in terms of sectoral output. Total output of tradable and nontradable intermediate goods is therefore given by

$$Y_{D,t} = z_{D,t}L_{D,t} - \frac{P_t}{p^I_{D,t}} z_{D,t}Bx^{\alpha}_{D,t}H_{D,t} \tag{15}$$

$$Y_{N,t} = z_{N,t}L_{N,t} - \frac{P_t}{p^I_{N,t}} z_{N,t}Bx^{\alpha}_{N,t}H_{N,t} \tag{16}$$

4 Wage Bargaining

Wages are set according to a Nash bargain, where the workers and firms split the surplus resulting from the match. The value of being employed in intermediate good sector i is given by

$$\begin{aligned} V^E_{i,t} = {} & W_{i,t} - \chi C^{\sigma}_{i,t}\tilde{L}^{\phi}_{i,t} + \\ & \beta \mathrm{E}_t \left\{ \left(\frac{C_t}{C_{t+1}}\right)^{\sigma} [(1-\delta(1-x_{i,t+1}))V_{i,t+1} + \delta(1-x_{i,t+1}))U_{i,t+1}] \right\}. \end{aligned} \tag{17}$$

where $W_{i,t} = \frac{w_{i,t}}{P_t}$ is the real wage. The first term represents the gap between the real wage and the marginal disutility of working, and the second is the discounted expected value of the next period's state – of the δ of employed workers who are separated, x will be rehired, so the probability of an employed worker being employed in the next period is $1-\delta+\delta x$, while the probability of being unemployed is $\delta-\delta x$. The value of unemployment in sector i is

$$V_{i,t}^{U}=\beta \mathrm{E}_t\left(\frac{C_t}{C_{t+1}}\right)^{\sigma}\left[x_{i,t+1}V_{i,t+1}^{E}+(1-x_{i,t+1})V_{i,t+1}^{U}\right] \qquad i=D,N. \tag{18}$$

The real surplus of a household in sector i from the match is given by

$$S_{i,t}^{H}=V_{i,t}^{E}-V_{i,t}^{U} \tag{19}$$

$$=W_{i,t}-\chi C_t^{\sigma}\tilde{L}_{i,t}^{\phi}+\beta(1-\delta)\mathrm{E}_t\left(\frac{C_t}{C_{t+1}}\right)^{\sigma}(1-x_{i,t+1})S_{i,t+1}^{H} \tag{20}$$

The real surplus to the firms from the match is given by the hiring cost (which they do not have to pay if they are in a match),

$$S_{i,t}^{F}=z_{i,t}Bx_{i,t}^{\alpha} \qquad i=D,N. \tag{21}$$

Nash bargaining implies that the household's share of the surplus is $S_{i,t}^{H}=\xi S_{i,t}^{F}$ where ξ represents the household's relative bargaining power. Therefore, real wages are given by

$$W_{i,t}=\chi C_t^{\sigma}\tilde{L}_{i,t}^{\phi}+\xi\left[z_{i,t}Bx_{i,t}^{\alpha}-\beta(1-\delta)\mathrm{E}_t\left(\frac{C_t}{C_{t+1}}\right)^{\sigma}(1-x_{i,t+1})z_{i,t+1}Bx_{i,t+1}^{\alpha}\right] \tag{22}$$

for $i=D,N$.

5 Pricing of Intermediate Goods

Intermediate goods firms in both sectors are owned by the representative household and therefore maximize

$$\mathrm{E}_t\sum_{s=0}^{\infty}Q_{t,t+s}\tilde{\Pi}_{i,t+s} \qquad i=D,N \tag{23}$$

where $Q_{t,t+s}=\beta^s\frac{P_t}{P_{t+s}}\left(\frac{C_t}{C_{t+s}}\right)^{\sigma}$ is the stochastic discount factor[3] and $\tilde{\Pi}$ represents instantaneous nominal profits, given by

$$\tilde{\Pi}_{i,t}=p_{i,t}^{I}z_{i,t}L_{i,t}-P_tz_{i,t}Bx_{i,t}^{\alpha}H_{i,t}-w_{i,t}L_{i,t} \qquad i=D,N. \tag{24}$$

In real terms, the firms' problem is to maximize

$$\mathrm{E}_t\sum_{s=0}^{\infty}\beta^s\left(\frac{C_t}{C_{t+s}}\right)^{\sigma}\Pi_{i,t+s} \tag{25}$$

[3] Letting λ designate the Lagrange multiplier on the household's budget constraint, $Q_{t,t+s}=\frac{\beta^s\lambda_{t+s}}{\lambda_t}$.

where real profits are

$$\Pi_{i,t} = \frac{p^I_{i,t}}{P_t} z_{i,t} L_{i,t} - z_{i,t} B x^{\alpha}_{i,t} H_{i,t} - W_{i,t} L_{i,t} \qquad i = D, N. \tag{26}$$

Noting that $H_{i,t} = L_{i,t} - (1-\delta)L_{i,t-1}$,

$$\Pi_{i,t} = \frac{p^I_{i,t}}{P_t} z_{i,t} L_{i,t} - z_{i,t} B x^{\alpha}_{i,t} (L_{i,t} - (1-\delta)L_{i,t-1}) - W_{i,t} L_{i,t} \qquad i = D, N. \tag{27}$$

The firms' optimality condition with respect to labor gives an expression for real intermediate goods price:

$$\frac{p^I_{i,t}}{P_t} = \frac{W_{i,t}}{z_{i,t}} + B x^{\alpha}_{i,t} - \beta(1-\delta)\mathrm{E}_t \left(\frac{C_t}{C_{t+1}}\right)^{\sigma} \frac{z_{i,t+1}}{z_{i,t}} B x^{\alpha}_{i,t+1} \qquad i = D, N. \tag{28}$$

Note that, in the absence of hiring costs, this reduces to the condition that the real wage is equal to the marginal product of labor and the additional terms represent the marginal cost of hiring and the discounted future hiring costs saved by hiring in the current period.

6 Pricing of Final Goods

Final goods producers in both the domestic tradable and nontradable sectors purchase intermediate goods and produce differentiated final goods, indexed by l. The demand for each variety of final goods is given by

$$c_{f,t}(l) = \left(\frac{p_{f,t}(l)}{P_{f,t}}\right)^{-\epsilon} C_{f,t} \qquad f = D, N \tag{29}$$

where ϵ represents the elasticity of demand for an individual variety, and $P_{f,t}$ is the overall price of sector f final goods. Following Calvo (1983), a fraction $1-\theta$ of firms can reset their prices in each time period. Letting $\tilde{p}_{f,t}$ denote the price set by price-changing firms, the overall price index evolves according to

$$P_{f,t} = \left[(1-\theta)\tilde{p}^{1-\epsilon}_{f,t} + \theta P^{1-\epsilon}_{f,t-1}\right]^{\frac{1}{1-\epsilon}} \qquad f = D, N. \tag{30}$$

The price-changing firms maximize

$$\sum_{s=0}^{\infty} \theta^s \mathrm{E}_t Q_{t,t+s} \left[\tilde{p}_{f,t} Y_{f,t+s|t} - \psi(Y_{f,t+s|t})\right] \qquad f = D, N \tag{31}$$

where $\psi(\cdot)$ is the cost function. A first-order Taylor expansion of the price-changing firms' first-order condition yields, after some algebra, sectoral New Keynesian Phillips Curves (NKPCs),

$$\pi_{f,t} \simeq \beta \mathrm{E}_t \pi_{f,t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \widehat{MC}_{f,t} \qquad f = D, N \tag{32}$$

where real marginal cost is expressed in terms of sectoral output, i.e., $MC_{f,t+s} \equiv \frac{mc_{f,t+s}}{P_{f,t+s}}$ and $\widehat{MC}_{f,t}$ represents the percentage deviation of real marginal cost from its steady state value, $\frac{1}{\mu}$. The nominal marginal costs for domestic final goods firms are the prices of the intermediate goods, i.e., $mc_{D,t} = p^I_{D,t}$ and $mc_{N,t} = p^I_{N,t}$.

7 Asset Markets and Interest Rates

The household's first order conditions imply the following conditions for the price of home- and foreign-currency denominated bonds

$$q_t = \beta \mathrm{E}_t \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \tag{33}$$

and

$$q^F_t = \beta \mathrm{E}_t \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \frac{e_{t+1}}{e_t}. \tag{34}$$

Noting that bond prices and interest rates, i, are related by $q_t = \frac{1}{1+i_t}$ and $q^F_t = \frac{1}{1+i^F_t}$, this implies that uncovered interest parity (UIP) holds in approximation; i.e.,

$$i_t - i^F_t = \mathrm{E}_t \frac{e_{t+1}}{e_t}. \tag{35}$$

As in Kollmann (2002), it is assumed that the small open economy cannot borrow internationally in its own currency (i.e., it is subject to "original sin"), which implies

$$B_t = 0 \qquad \forall t. \tag{36}$$

The interest rate at which the economy can borrow internationally increases with its debt; i.e., increasing borrowings raise the risk premium it pays relative to the exogenous world interest rate, i^w,

$$i^F_t = i^w_t - \psi B^F_t. \tag{37}$$

This is one of the methods shown by Schmitt-Grohe and Uribe (2003) to ensure the stationarity of a small open economy model.

8 Demand and Goods Market Clearing

Output is demand-determined. For nontradable goods, this implies

$$Y_{N,t} = C_{N,t} = (1-\omega) \left(\frac{P_{N,t}}{P_t} \right)^{-\eta} C_t. \tag{38}$$

For domestic tradables, output satisfies demand for home consumption and exports

$$Y_{D,t} = C_{D,t} + X_t \tag{39}$$

where

$$C_{D,t} = \gamma\omega \left(\frac{P_{D,t}}{P_{T,t}}\right)^{-\nu} \left(\frac{P_{T,t}}{P_t}\right)^{-\eta} C_t \tag{40}$$

and

$$X_t = \kappa \left(\frac{1}{e_t} P_{D,t}\right)^{-\nu} F_t \tag{41}$$

where κ is a constant, $\frac{1}{e}P_D$ is the price of domestic tradable goods converted to foreign currency and F_t is foreign demand, which is a source of exogenous shocks.

Imports, M, are given by

$$M_t = C_{M,t} = (1-\gamma)\alpha \left(\frac{eP_t^w}{P_{T,t}}\right)^{-\nu} \left(\frac{P_{T,t}}{P_t}\right)^{-\eta} C_t \tag{42}$$

where P^w is the (exogenous) world price of tradable goods, and eP^w is that price in domestic currency.

The small open economy's trade balance is equal to its accumulation of foreign assets

$$p_{D,t}X_t - e_t p_t^w c_{M,t} = e_t q_t^F B_{t+1}^F - e_t B_t^F. \tag{43}$$

9 Monetary Policy

Several alternative monetary policies are considered. One possibility is stabilization of the rate of change in the overall (consumer) price level, P, i.e.,

$$\pi_t^{CPI} = 0 \tag{44}$$

Another monetary rule would stabilize the price of domestically-produced goods (i.e., the producer price index),

$$\pi_t^{PPI} = 0 \tag{45}$$

where producer price index inflation is a weighted average of tradable and non-tradable goods inflation, $\pi_t^{PPI} = s\pi_{D,t} + (1-s)\pi_{N,t}$.

Monetary policies that attempt to balance goals of stabilizing prices and output - e.g., the US Federal Reserve's "dual mandate" - can be modeled with policy rules of the "Taylor rule" form:

$$i_t = \bar{i} + \phi_\pi \pi_t + \phi_y y_t^g \tag{46}$$

where $\bar{i} = -\ln\beta$ is the interest rate in the zero inflation steady state, $\pi \in \{\pi^{CPI}, \pi^{PPI}\}$ and y^g is the output gap. The output gap is calculated as the percentage deviation of output from its "natural" level, Y^n. For each sector, natural output is approximated by

$$Y_{i,t}^n \simeq z_{i,t}(\bar{L}_i - \mu\bar{G}_i\bar{H}_i) \qquad i = D, N \tag{47}$$

where the bars denote steady state levels. That is, the natural level of output rises and falls with productivity while maintaining labor and hiring costs at their steady state equilibrium. The output gap is

$$y_t^g = s\left(\ln Y_{D,t} - \ln Y_{D,t}^n\right) + (1-s)\left(\ln Y_{N,t} - \ln Y_{N,t}^n\right). \tag{48}$$

10 Parameterization

Canada is utilized as a benchmark example of a small open economy to set values for the model's share parameters. The share of household in the tradable sector, s, is set to 0.27 based on the share of employment in goods-producing industries[4]. The sectors are assumed to have the same productivity (normalized to unity in the steady state), which implies that the share of tradables in consumption is $\omega = 0.27$. The share of imports in the tradable goods bundle, $1-\gamma$, is based on imports of consumption goods as a share of goods consumption (26.7%)[5] and adjusted for a 41.2% distribution margin (Burstein, Neves and Rebelo's (2003) estimate for Canada) to yield $1-\gamma = 0.454$. These parameters give a somewhat smaller import-GDP ratio than Canada's (12%, versus an average of 31% in data over 1981-2007), but Canadian imports, like those of many small open economies, likely include a substantial share of intermediate goods, and intermediate goods trade is not included in the model. To maintain symmetry under balanced trade in the steady state, $\kappa = (1-\gamma)\omega$.

The separation rate, δ, is set to 10%, which is the value used by Walsh (2005) and close to the quarterly value implied by Shimer's (2005) monthly estimate of 3.5%, which is used by Thomas (2011). It is in between the "fluid" (US) and "sclerotic" (European) cases examined by BG. The constant in the hiring cost function is set at $B = 0.1875$, which yields steady state hiring costs of 1% of output, as in BG, and a steady state unemployment rate of 8%, which is a typical value for Canada. Following BG, $\chi = 1.03$ and $\alpha = 1$. Households and firms are assumed to have equal bargaining power, with $\xi = 0.5$.

Other parameters are set at mainstream values in the literature. The intertemporal elasticity is set at $\sigma = 1$ and the inverse Frisch elasticity of labor supply is $\phi = 2$. Domestic and imported tradables are assumed to be complements, with an elasticity given by $\nu = 1.5$, while tradables and nontradables are complements with $\eta = 0.44$ based on Stockman and Tesar's (1995) estimate. The probability of not receiving a price change signal is $\theta = 0.75$, the elasticity between varieties is 6, giving a markup of 20%. The (quarterly) discount factor is $\beta = 0.99$ and the risk premium coefficient on foreign bonds is $\psi = 0.01$. For cases using a Taylor rule, the canonical values of $\phi_\pi = 1.5$ and $\phi_y = 0.125$ are used (ϕ_y is one-fourth the usual value of 0.5 because the interest and inflation rates are expressed in quarterly terms).

[4]Based on employment in goods- and service-producing industries from CANSIM table 282-0088, 1981-2007.

[5]Based on the sum of imports of agricultural and fishing products, passenger autos and chassis, trucks and other motor vehicles and other consumer goods from CANSIM table 228-0043 as a share of expediture on consumer goods from CANSIM table 380-0017, 1981-2007.

11 Solution and Results

The model is log-linearized around the steady-state[6] and solved using Dynare (Adjemian et al, 2011). The dynamics are analyzed below for shocks to five exogenous variables. To isolate the impact of each type of shock, they are assumed to be independent, with no spillovers. For technology, world prices and foreign demand, percent deviations from the steady state (denoted with carets) follow the following processes

$$\hat{z}_{D,t} = \rho\hat{z}_{D,t-1} + \varepsilon_t^D \tag{49}$$

$$\hat{z}_{N,t} = \rho\hat{z}_{N,t-1} + \varepsilon_t^N \tag{50}$$

$$\hat{P}_t^w = \rho\hat{P}_{t-1}^w + \varepsilon_t^P \tag{51}$$

$$\hat{F}_t = \rho\hat{F}_{t-1} + \varepsilon_t^F \tag{52}$$

where $\rho = 0.9$ and the ε shocks are $iid \sim N(0, 0.01)$. For world interest rates, shocks occur to the difference between i_t^W and its steady state value $-\ln\beta$. That is,

$$\tilde{i}_t^W = \rho\tilde{i}_{t-1}^W + \varepsilon_t^i \tag{53}$$

where $\tilde{i}^W = i^W + \ln\beta$ and the standard deviation of ε^i is 25 basis points, which is approximately 1 percentage point at an annual rate.

11.1 Productivity Shocks

Figure 1 shows the response of interest rates (annualized), the exchange rate, tradable and nontradable sector unemployment and inflation rates to a positive 1% tradable sector productivity shock.

A sectoral productivity shock creates a conflict for the monetary authority: in the tradable sector, the positive technology shock is deflationary and creates an output gap. Since price adjustment is sluggish, output rises, but not enough to prevent unemployment from increasing significantly. However, nontradable sector variables move in the opposite direction: prices rise and unemployment falls. This is due to complementarity between tradables and nontradables – when the shock causes output and consumption of tradables to rise, demand for nontradables increases.

The increased supply of domestic tradables causes the exchange rate to depreciate (an increase in e, the price of foreign currency). Although both inflation target policies initially raise rates to respond to the increase in nontradable inflation, over time, the PPI-based policies are more accommodating with lower rates. This is because PPI-based policies disregard the inflationary pressure from exchange rate deprecation while assigning more weight to domestic tradables prices, which are falling. Furthermore, because the interest rates are lower under PPI-based policies, the exchange rate depreciation is greater.

[6]Although linearization may be inappropriate for welfare analysis (Kim and Kim, 2003), it is generally considered acceptable for analyzing model dynamics.

Following a positive productivity shock in the nontradable goods sector, nontradable unemployment rises, while tradable unemployment falls (figure 2). The logic is analogous to the case of the tradable sector productivity shock discussed above – complementarity causes demand to increase for a sector's output when the other sector experiences a productivity increase. However, the magnitude of the decrease in the tradable sector unemployment rate is larger than for the nontradable sector in figure 1 because the tradable sector is smaller, so the increased demand due to higher consumption of complementary nontraded goods generates a larger percentage change in tradable output.

Increased demand for tradables includes higher demand for imports, which causes the exchange rate to depreciate. The CPI-based inflation target therefore generates a larger increase in interest rates than the PPI-based rule, which raises rates to respond to rising tradable prices (which, in this parameterization initially outweighs the deflation in the nontradable sector) but disregards rising import prices due to the exchange rate movement. While the Taylor rule policies have lower interest rates than the inflation targets due to the response to the output gap in the larger sector of the economy (nontradables), the PPI-based Taylor rule leads to lower rates than the CPI-based rule because of the difference in whether the exchange rate affects the relevant inflation rate.

For both the tradable and nontradable productivity shocks, the impulse responses highlight the important difference between CPI and PPI-based rules in relationship to the exchange rate. Although the exchange rate is an endogenous variable, in both cases, the technology shock leads to a depreciation, which affects consumer, but not producer prices, and the policy responses differ accordingly.

11.2 World Price Shocks

Responses to a 1% positive shock to world prices, P^w, are shown in figure 3. This case generates an especially large divergence between the consumer- and producer-price based monetary rules. The CPI inflation target leads to a large increase in interest rates to offset the inflationary effect of import prices. The monetary tightening under the CPI Taylor rule is less severe because it also takes into account the effect on output. In contrast, the PPI-based rules essentially allow the monetary authority to ignore the external shock because import prices do not enter the monetary rule.

An increase in the price of imports causes demand for domestic tradables to rise and results in rising prices and falling unemployment in the tradable sector, except in the case of a CPI target, where the monetary tightening is severe enough that the unemployment rate actually increases and prices fall. Because of the increase in the price of imports, demand for nontradables falls, but the rise in nontradable unemployment is much more severe under the CPI target due to the additional effect of the monetary tightening.

The large increase in interest rates under the CPI target generates a significant exchange rate appreciation. Essentially, the need to offset the increase in the price of foreign goods under a CPI target requires policy to force a currency appreciation as well as deflation in domestic goods prices.

11.3 Foreign Demand Shocks

Responses of to an increase in foreign demand, F, are shown in figure 4. Higher demand leads to inflation and decreasing unemployment in the domestic tradable goods sector. The greater foreign demand also causes an appreciation of the currency (i.e., e decreases).

In this case, PPI-based policies lead to higher interest rates because they respond to the positive contribution of domestic tradable prices to PPI inflation while disregarding the influence of the exchange rate movement on consumer prices. CPI-based policies are more expansionary because they account for the offsetting influence of the exchange rate appreciation.

Taylor rule policies lead to higher interest rates than the inflation target policies because the increase in demand causes tradable sector output to be above its natural level.

11.4 World Interest Rate Shocks

Figure 5 shows responses to a one percentage point (annualized) increase in world interest rates. Higher returns on foreign bonds cause the exchange rate to depreciate. The exchange rate movement causes the quantity demanded of domestic tradables to rise in the rest of the world. In the domestic tradables sector, prices rise and unemployment falls. While exports increase, domestic consumption of tradables decreases, so demand falls and unemployment increases in the nontradables sector.

The CPI-based rules lead to a severe tightening of policy because they must respond to direct effect of the exchange rate depreciation on the CPI, while the PPI-based rules disregard it. Because the shock is inflationary in the tradable goods sector and deflationary in the nontradable sector, the response of PPI-based policies is muted.

Compared to the other rules, the large interest rate increase necessitated by the CPI target results in a much larger rise in nontradable sector unemployment and a smaller decrease in tradable unemployment.

11.5 Moments

Table 1 reports standard deviations generated by the model for selected variables. Under the assumed parameters and shock processes, the choice of monetary rule only makes a modest difference for the volatility of output and consumption, though the CPI inflation target is the rule which leads to the greatest volatility of both.

The standard deviations of the unemployment rates are expressed in percentage points. A PPI-based Taylor rule generates slightly less unemployment volatility than a CPI-based one because the volatility of tradable unemployment is less. The CPI inflation target leads to considerably higher unemployment volatility than the other rules, primarily because the nontradable sector unemployment rate is more volatile under the CPI target.

12 Conclusions

The results above suggest that monetary rules focused on domestic (producer) prices generally are better at stabilizing unemployment. Of the four rules considered, consumer price inflation targets, which are widely used by central banks, lead to the largest unemployment fluctuations in the sector experiencing the largest shift in response to productivity, world price and foreign demand shocks. The CPI target also generates the smallest offsetting unemployment rate movements in the other sector for the productivity and foreign demand shocks, and in the case of a world price shock, it leads unemployment rates in both sectors to move in the same direction. In the case of a world interest rate shock, a CPI target reduces the unemployment movement in the tradable sector, while increasing it in the nontradable sector. The need, under a CPI target, to respond to exchange rate movements because they directly enter the consumer price index plays a key role in the higher volatility generated by this rule.

This paper represents a first step in investigating the interaction between monetary policy and unemployment rates in open economies. A number of extensions could be fruitful in developing a model that might be able to replicate features of the data to provide more detailed guidance to policy makers.

A particularly important issue for future research would be to investigate alternative specifications of how the exchange rate is transmitted to consumer prices. In a model where imports are intermediate goods and sticky prices lead to imperfect pass-through, Smets and Wouters (2002), find that more weight should be attached to stabilizing the exchange rate. Adolfson (2007) also finds that, under imperfect pass through, responding to exchange rates is optimal and notes that this can be achieved indirectly through the response to consumer prices. Flamini (2007) examines how pass through that is imperfect due to both sticky prices and because the final good uses imported intermediate goods constrains the ability of a CPI-targeting central bank to limit output volatility. In a multisector model based on Canada, with imperfect pass through and sticky wages, DeResende et al. (2010) find that CPI stabilization yields higher welfare if intersectoral capital mobility is limited.

Previous studies have investigated how some of the parameter choices have implications for optimal monetary policy – Faia and Monacelli (2008) have shown that the degree of home bias is important and De Paoli (2009a) examines the substitutability between domestic and imported goods. Furthermore, a number of papers, including De Paoli (2009b), have considered the role that risk sharing through international asset trade in optimal monetary policy. However, these papers are focused on welfare measures and these issues remain to be invested in a model with unemployment.

Other features which could be useful for building a quantitative model for policy analysis to include capital, sticky wages, and habit formation in preferences. For particular countries, the relative size of tradable versus nontradable sectors, as well as the types of shocks the economy experiences, will clearly be crucial in determining appropriate policies.

References

Adjemian, Stéphane, Houtan Bastani, Michel Juillard, Ferhat Mihoubi, George Perendia, Marco Ratto and Sébastien Villemot, 2011. Dynare: Reference Manual, Version 4. Dynare Working Papers 1. CEPREMAP.

Adolfson, M., 2007. Incomplete Exchange Rate Pass-Through and Simple Monetary Policy Rules. Journal of International Money and Finance 26: 468-494.

Andolfatto, D., 1996. Business Cycles and Labor-Market Search. American Economic Review 86: 112-132.

Blanchard, O. and J. Gali, 2010. Labor Markets and Monetary Policy: A New Keynesian Model with Unemployment. American Economic Journal: Macroeconomics 2: 1-30.

Calvo, G., 1983. Staggered Prices in a Utility-Maximizing Framework. Journal of Monetary Economics 12: 383-398.

Christiano, L., M. Trabandt and K. Walentin, 2011. Introducing Financial Frictions and Unemployment into a Small Open Economy Model. Journal of Economic Dynamics & Control 35: 1999-2041.

DePaoli, B., 2009a. Monetary Policy and Welfare in a Small Open Economy. Journal of International Economics 77: 11-22.

DePaoli, B., 2009b. Monetary Policy Under Alternative Asset Market Structures: The Case of a Small Open Economy. Journal of Money, Credit and Banking 41: 1301-1330.

DeResende, C., A. Dib and M. Kichian, 2010. Alternative Optimized Monetary Policy Rules in Multi-Sector Small Open Economies: The Role of Real Rigidities. Bank of Canada Working Paper 2010-9.

Faia, E. and T. Monacelli, 2008. Optimal Monetary Policy in a Small Open Economy with Home Bias. Journal of Money Credit and Banking 40: 721-750.

Flamini, A., 2007. Inflation Targeting and Exchange Rate Pass-Through. Journal of International Money and Finance 26: 1113-1150.

Gali, J. and T. Monacelli, 2005. Monetary Policy and Exchange Rate Volatility in a Small Open Economy. Review of Economic Studies 72: 707-734.

Gertler, M. and A. Trigari, 2009. Unemployment Fluctuations with Staggered Nash Wage Bargaining. Journal of Political Economy 117: 38-86.

Kim, J. and S. Kim, 2003. Spurious Welfare Reversals in International Business Cycle Models. Journal of International Economics 60: 471-500.

Kollman, R., 2002. Monetary Policy Rules in the Open Economy: Effects on Welfare and Business Cycles. Journal of Monetary Economics 49: 989-1015.

Merz, M., 1995. Search in the Labor market and the Real Business Cycle. Journal of Monetary Economics 36: 269-300.

Obstfeld, M., and K. Rogoff, 1995. Exchange Rate Dynamics Redux. Journal of Political Economy 103: 624-660.

Schmitt-Grohe, S. and M. Uribe, 2003. Closing Small Open Economy Models. Journal of International Economics 61: 163-185.

Shimer, R., 2005. The Cyclical Behavior of Equilibrium Unemployment and Vacancies. American Economic Review 95:25-49.

Smets, F. and R. Wouters, 2002. Openness, Imperfect Exchange Rate Pass-Through and Monetary Policy. Journal of Monetary Economics 49: 947-981.

Stockman, A. and L. Tesar, 1995. Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements. American Economic Review 85: 168-185.

Svensson, L. 2000. Open-Economy Inflation Targeting. Journal of International Economics 50: 155-183.

Thomas, C., 2008. Search and Matching Frictions and Optimal Monetary Policy. Journal of Monetary Economics 55: 936-956.

Thomas, C., 2011. Search Frictions, Real Rigidities and Inflation Dynamics. Journal of Money, Credit and Banking 43: 1131-1164.

Trigari, A., 2009. Equilibrium Unemployment, Job Flows and Inflation Dynamics. Journal of Money, Credit and Banking 41: 1-33.

Walsh, C. 2005. Labor Market Search, Sticky Prices and Interest Rate Policies. Review of Economic Dynamics 8: 829-849.

Figure 1. Responses to Tradable Sector Productivity Shock

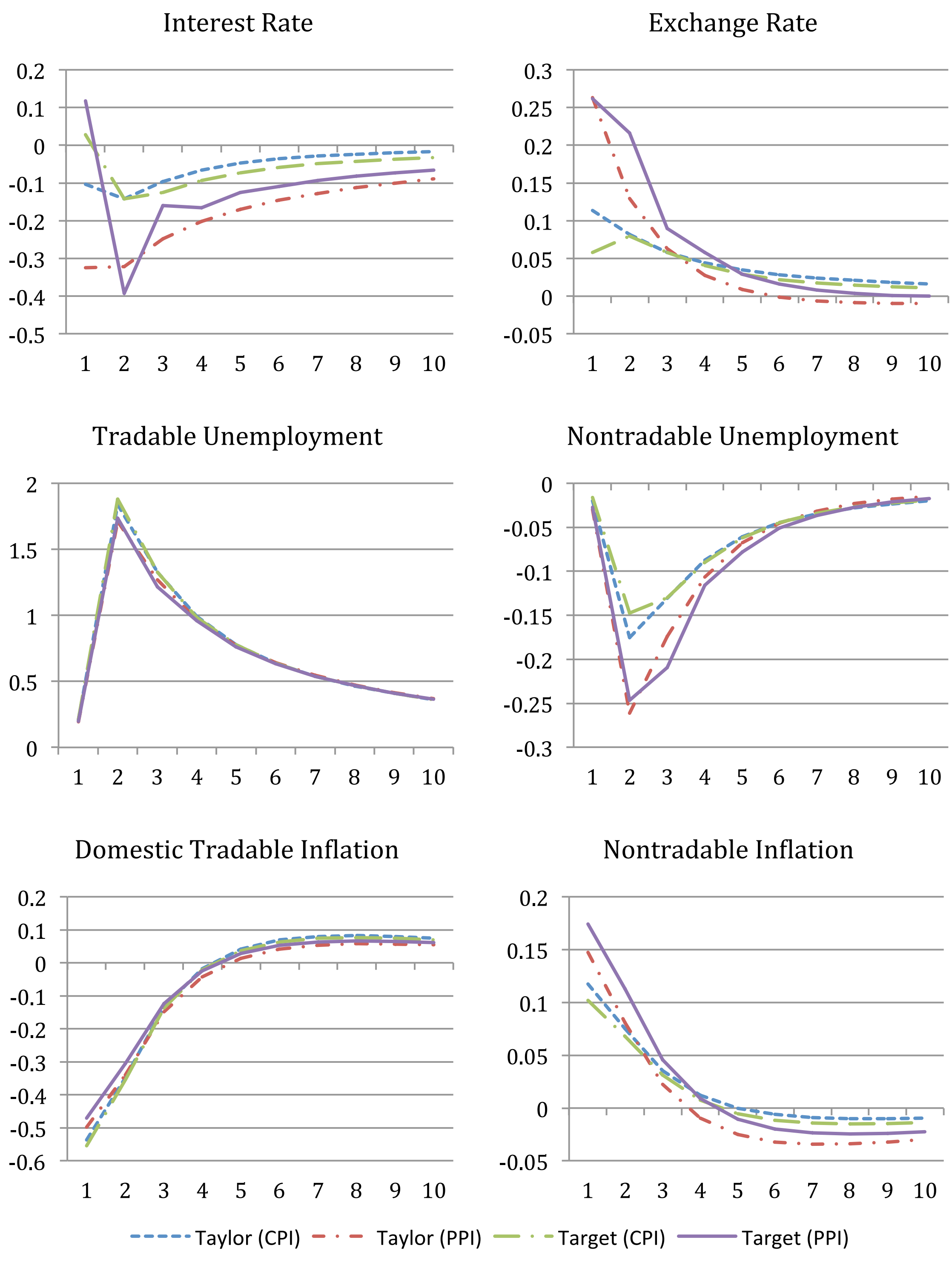

Figure 2. Responses to Nontradable Sector Productivity Shock

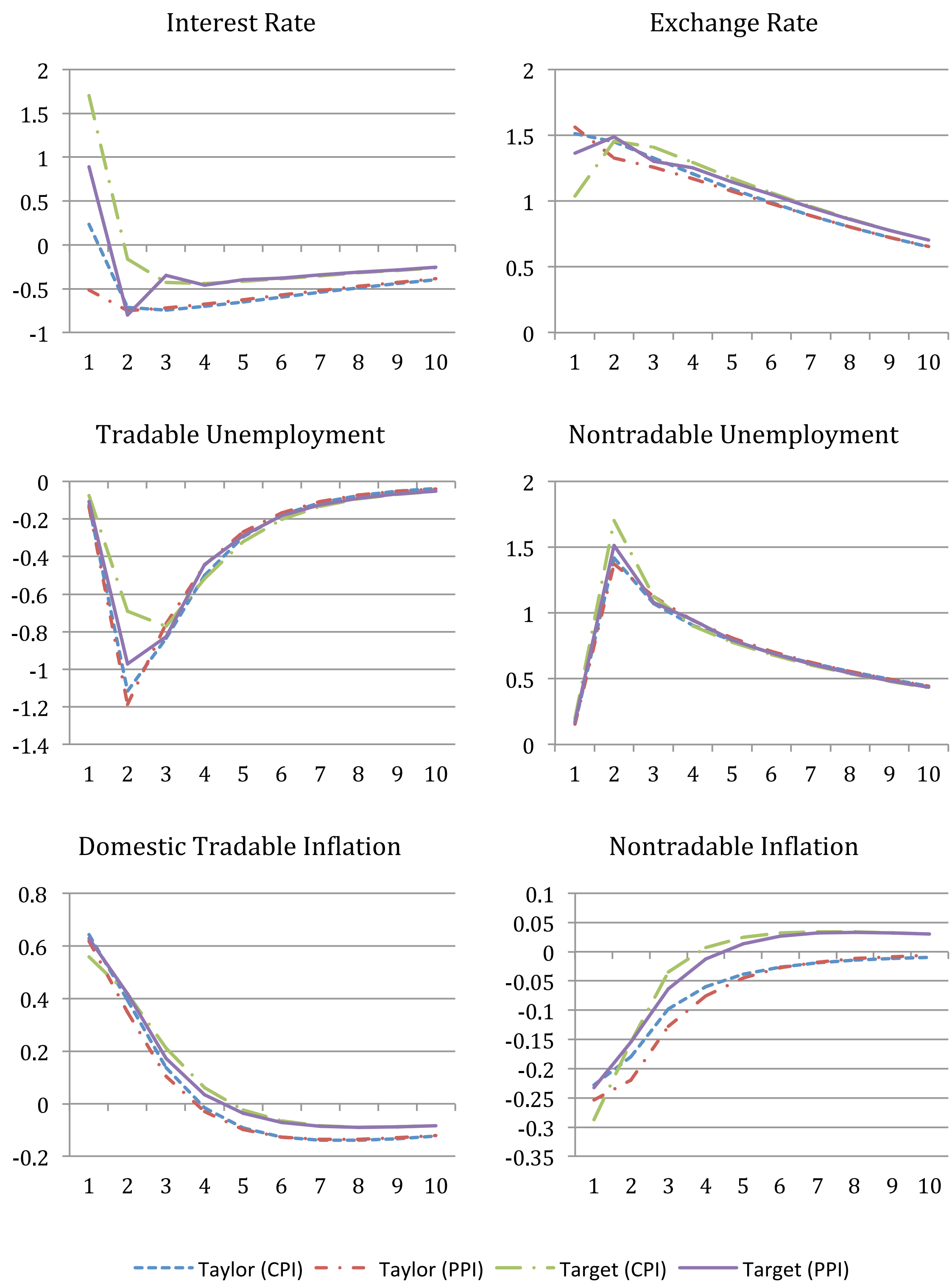

Figure 3. Responses to World Price Shock

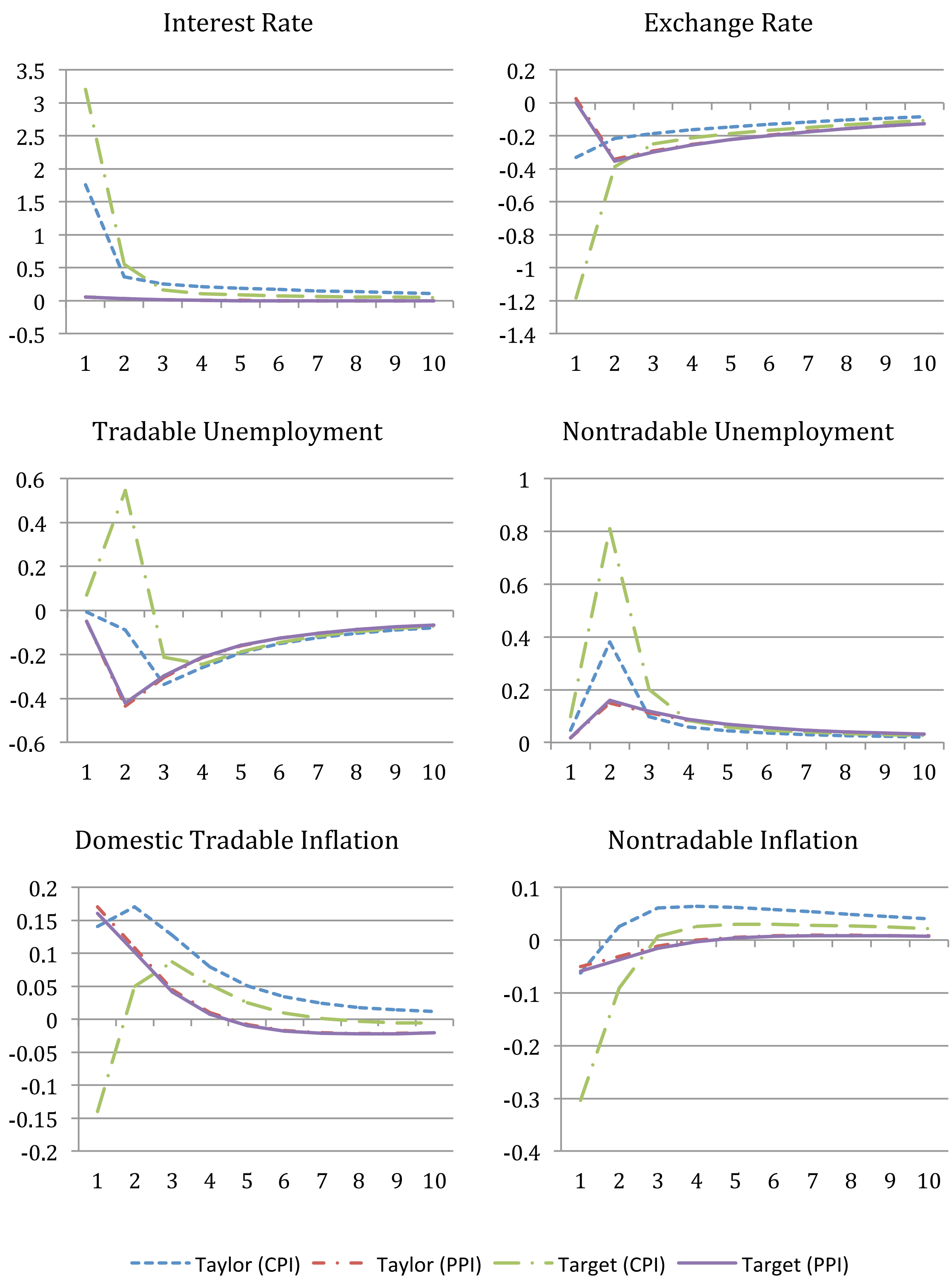

Figure 4. Responses to Foreign Demand Shock

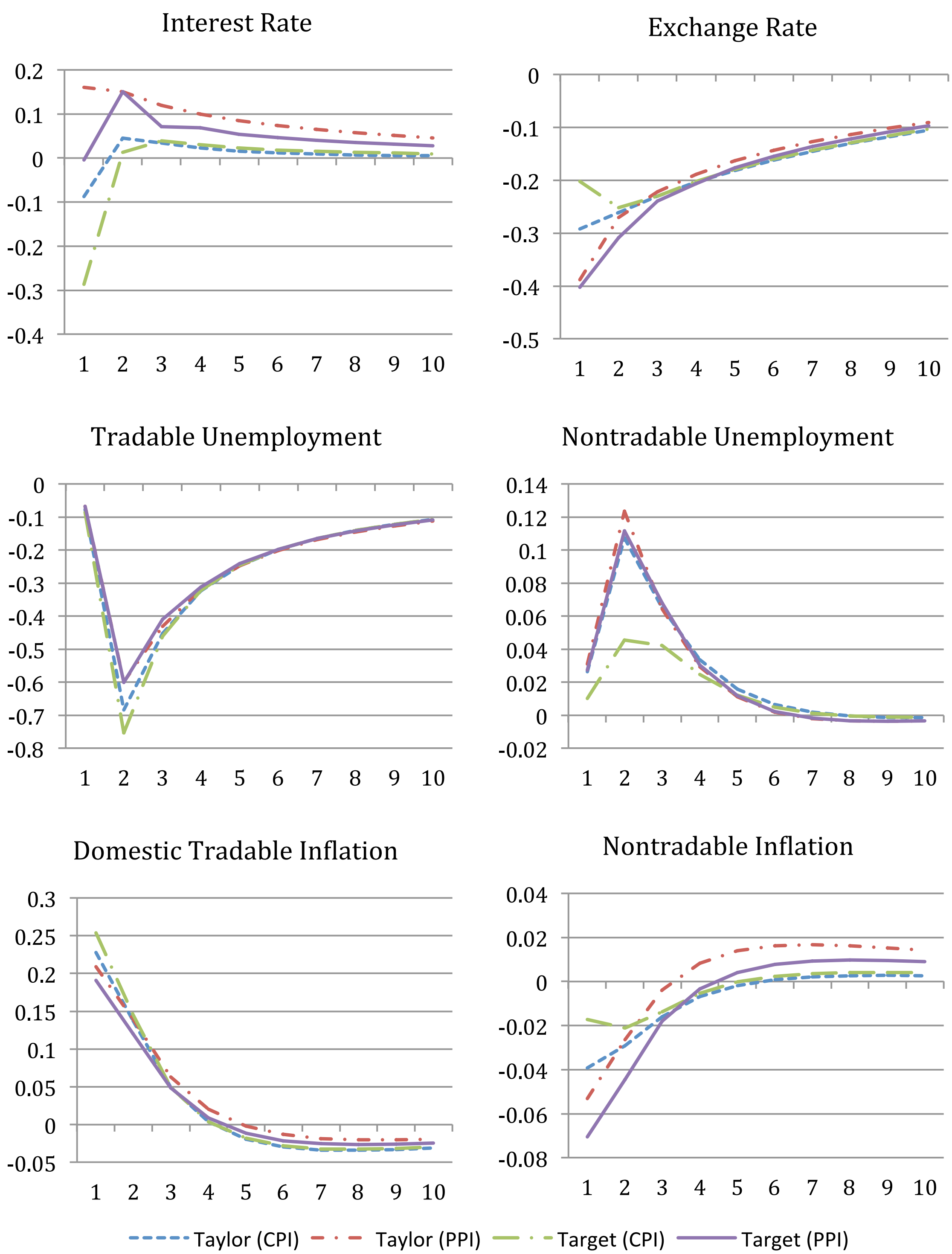

Figure 5. Responses to Foreign Interest Rate Shock

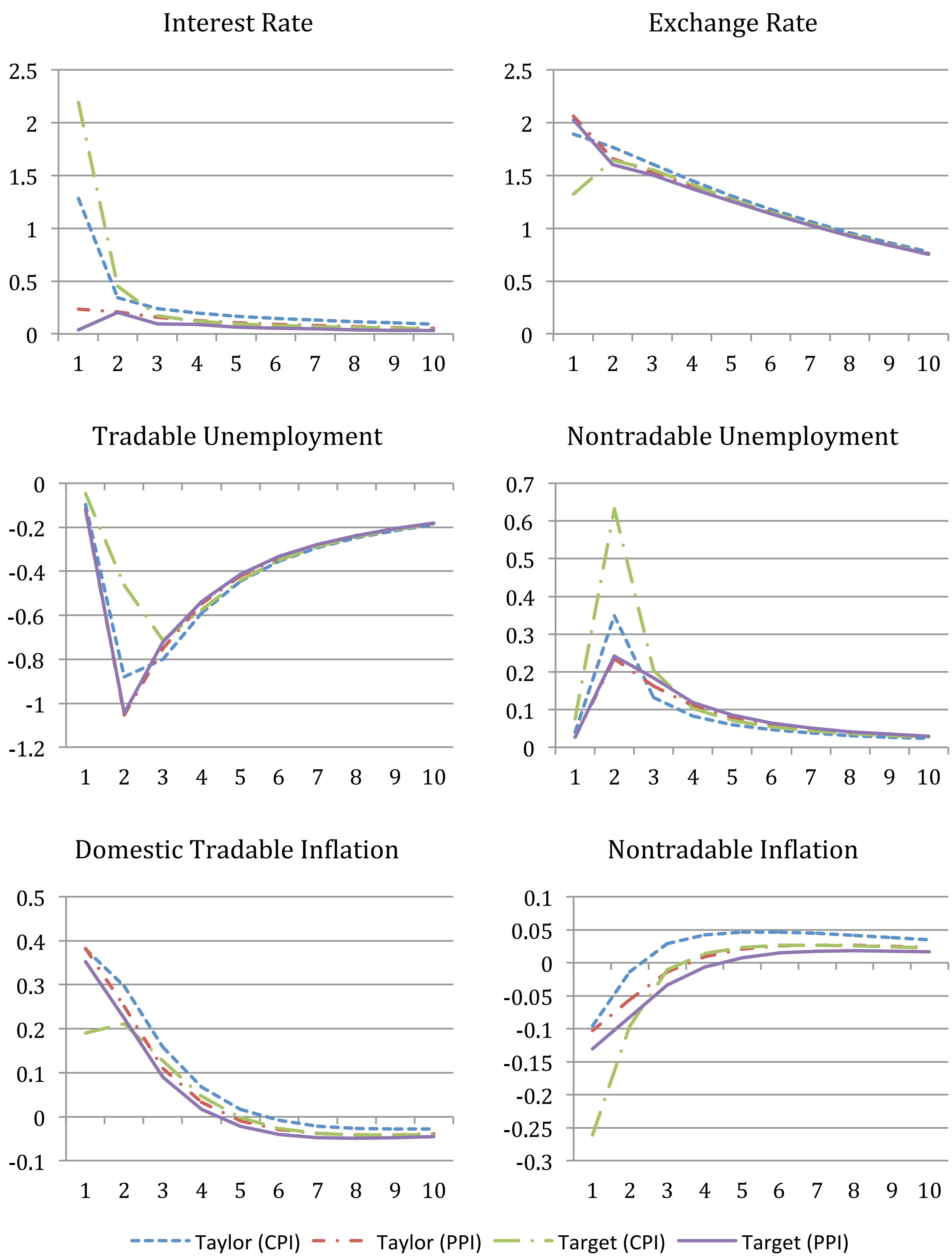

Table 1. Standard Deviations of Selected Variables

	Taylor Rule		Inflation Target	
	CPI	PPI	CPI	PPI
Output (%)	3.73	3.70	3.74	3.68
Consumption (%)	3.86	3.80	3.99	3.80
Tradable Unemployment Rate	3.83	3.76	3.68	3.68
Nontradable Unemployment Rate	2.74	2.74	3.03	2.78
Overall Unemployment Rate	1.76	1.73	2.06	1.75