Monetary Policy, Trade, and Commodity Price Fluctuations*

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October 8, 2024

Abstract

This paper explores the benefits of inflation targeting and flexible exchange rates in response to commodity price shocks. Using local projection methods, we estimate how exchange rates and industrial production react to these shocks before and after adopting inflation targeting. Our results show that exchange rates become more responsive, while industrial production becomes less affected after inflation targeting is implemented. This suggests a strong expenditure-switching effect, even in countries where manufacturing exports are priced in U.S. dollars. We explain the data using a novel model with firm heterogeneity, endogenous trade participation, and nominal rigidity. Our model introduces an expenditure-switching channel under dominant currency pricing, which is absent in standard New Keynesian models. In this framework, an increase in commodity prices raises production costs, slowing the entry of new producers into manufacturing. As only higher-productivity firms can enter the export market, the average productivity improves. When export prices are sticky in the dominant currency, the decrease in export prices is limited and the exchange rate appreciates. The latter reduces marginal costs in return, and encourages more entry, thereby mitigating the impact of rising commodity prices. Moreover, we show that inflation targeting combined with flexible exchange rates leads to higher welfare than alternative monetary policy regimes in the face of commodity price shocks.

JEL codes: E52, F21, F31, F41.

Keywords: Monetary Policy; Expenditure Switching; Exchange Rate; Commodity Shocks.

*Preliminary. We thank seminar and conference participants at the Annual Conference of the Canadian Economics Association and the Czech National Bank. All errors are ours.

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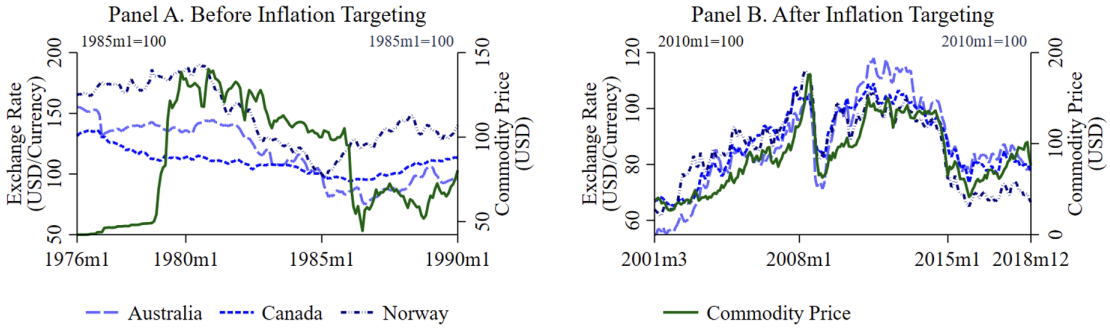
1 Introduction

Small commodity-exporting countries such as Australia, Canada and Norway are the strongest proponents of a flexible exchange rate. These countries' manufacturing exports are generally invoiced in the US dollars. They also typically have an inflation-targeting monetary policy framework.

For small commodity exporters, a flexible exchange rate facilitates adjustment to global commodity price movements in these economies by affecting relative prices and promoting a reallocation of factors between the tradable sector and the commodity and the non-tradable sectors.[1] However, Goldberg and Tille (2008) and Gopinath (2016) point out that most of the export invoicing is in U.S. dollars, even in trade between other countries excluding the United States. When exports are priced in the dominant currency, an implication is that export prices are less sensitive to exchange rate movements and the demand and supply adjustment mechanism via relative sales prices is dampened. On the contrary, the data suggests high correlation between export price indices and the exchange rates (Obstfeld (2020)).

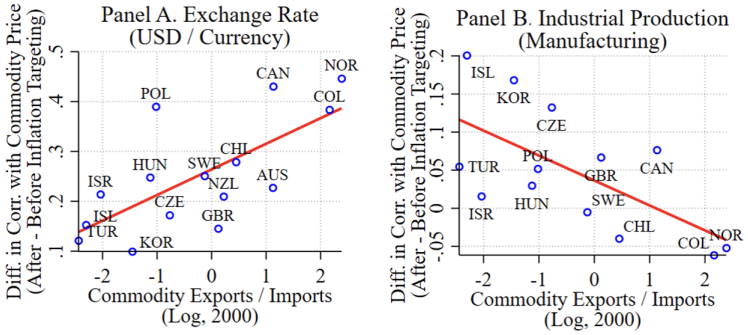
We document that an important amount of the reallocation occurs at the extensive margin under dominant currency pricing—through changes in the number of producers in the manufacturing sector—due to movements in marginal costs. By focusing on the commodity exporter countries of Australia, Canada, and Norway, we provide the time series of the exchange rate against the USD with the price of World Bank Commodity Price Index before and after these countries introduced inflation targeting (Figure 1, Panel A and B, respectively). An increase (decrease) implies an appreciation (depreciation) of domestic currency against the U.S. dollar. Figure 1 indicates that oil prices get highly correlated with the exchange rate after the introduction of inflation targeting. Figure 2 illustrates the change in the correlation between commodity prices and the exchange rate (Panel A) and the change in the correlation between commodity prices and industrial production before and after the introduction of inflation targeting. The horizontal axis indexes whether the countries are commodity exporters or importers. Figure 2 shows that, after the adoption of inflation targeting, the correlation between commodity exporters' exchange rate and commodity prices goes up. Whereas, the correlation between commodity exporters' industrial production and commodity

Figure 1: Commodity Price and the Exchange Rate



Notes: Australia, Canada, and Norway switched to an inflation targeting regime in between 1990 and 2001. Commodity price is the World Bank Commodity Price Index.

Figure 2: Commodity Price, Exchange Rate, and Industrial Production



Notes: Differences in correlation of the exchange rate with commodity prices and industrial production with commodity prices, before and after the introduction of inflation targeting. The horizontal axis indexes whether a country is a commodity exporter or an importer.

prices goes down after the adoption of inflation targeting.

Motivated by these correlations, empirically, we study the relevance of commodity prices on the exchange rate and industrial production in a panel of commodity exporter and importer economies: Israel, Turkey, Iceland, Korea, Poland, Czechia, Hungary, Sweden, Canada, Colombia, Great Britain, and Norway. We estimate impulse responses to identified commodity price shocks by local projections, following Jorda (2005).

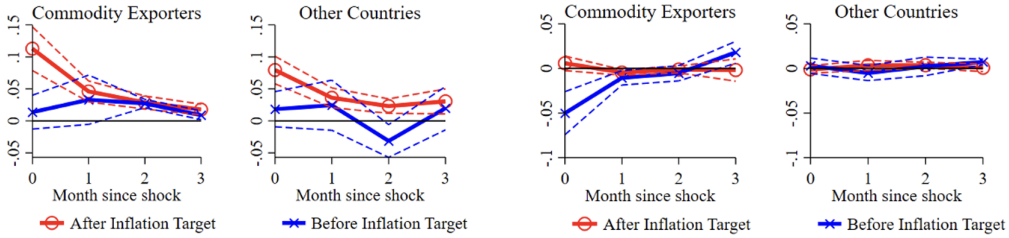
Empirically, a shock that increases commodity prices generates an appreciation of currency in commodity exporting economies after the adoption of inflation targeting. Moreover, industrial production in manufacturing sector becomes less responsive to the commodity price shocks after the adoption of inflation targeting.

Our empirical findings call for a new model. To shed light on the link between exchange rates, trade dynamics, and commodity price fluctuations, we develop a small open economy model of international trade and macroeconomic dynamics in the spirit of Ghironi and Melitz (2005). The model builds on the dynamic version of Melitz's (2003) trade model and augments it with a commodity sector. We also introduce nominal rigidities and internationally incomplete financial markets. These features imply a role for international relative prices, which interact with accumulation of net foreign assets, in shaping the transmission of shocks between sectors through endogenous changes in extensive margin of trade.

Our simulations indicate that our model captures both the positive correlation between exchange rates and commodity prices and the negative correlation between exchange rates and producer entry in manufacturing. After an increase in global oil prices, marginal costs in manufacturing rise and only higher productivity firms are able to enter. The fall in the total number of firms translate into fewer exporters, with lower productivity exporters dropping from the export market. Producer reallocation within exporters puts downward pressure on export price index. When export prices are sticky in the local currency, the pressure on export price index is released by an exchange rate appreciation. This appreciation in the exchange rate, in turn, lowers the marginal costs of production, facilitating higher entry. Endogenous producer entry and selection into trade facilitate the adjustment of resources and accentuates the benefit of a flexible exchange rate in absorbing commodity price shocks.

[1] Among others, see Corden and Neary (1982).

Figure 3: Impulse Responses to a Commodity Price Shock



(a) Exchange Rate (USD/Currency) (b) Industrial Production (Manufacturing)

Notes: The red lines indicate impulse responses for the indicated set of countries after they adopt inflation targeting, whereas blue lines indicate impulse responses for the same set of countries before they adopt inflation targeting.

We also provide an evaluation of the welfare consequences of flexible exchange rates under inflation targeting by comparing it to fixed exchange rate regime under commodity price shocks. We calculate a welfare compensating variation in consumption for the small open economy households. We find that the households prefer the flexible exchange rates with an inflation-targeting monetary policy framework to fixed exchange rates.

The rest of the paper is organized as follows. Section 2 discusses our empirical findings. Section 3 presents the model. Section 3 discusses the calibration and results. Section 4 compares the welfare implications of inflation targeting to those of fixed exchange rates. Section 5 concludes. An appendix contains additional details and results.

2 Empirical Analysis

In this section, we examine the effects of commodity price shocks in the data. We estimate impulse responses by local projections by employing the methodology in Jorda (2005). Our sample is composed of data from Israel, Turkey, Iceland, Korea, Poland, Czechia, Hungary, Sweden, Canada, Colombia, Great Britain, and Norway.

Figure 3 shows that commodity exporter countries' exchange rate comoves strongly with the commodity price shocks after the inflation targeting, whereas their manufacturing sector becomes less responsive to the commodity price shocks after the inflation targeting. We interpret this as inflation targeting helps commodity exporters to isolate their manufacturing sector from commodity price shocks.

3 The Model

We develop a small open economy model of international trade and macroeconomic dynamics. The small open economy is of measure zero relative to the rest of the world, and hence, fluctuations in the small open economy have no effect outside of the domestic economy.

There are four types of agents in the model: households, commodity good producers, intermediate good producers, and monopolistically competitive manufacturers. The commodity good is produced by labor and it serves as an input for intermediate good production. Moreover, it can be traded across the border. Manufacturing firms are heterogeneous in terms of their relative productivity. Only an endogenous fraction of relatively more productive manufacturing firms export, while the remaining only serve their domestic market. The currency of international trade is in the rest of the world currency. International financial markets are incomplete as only non-contingent assets are internationally traded.

In what follows, we focus on the small open economy (Home), and, otherwise indicated, the rest of the world has a symmetric structure.

Figure 4 shows the model architecture.

3.1 Household Preferences

The economy is populated by atomistic households. Each household is a monopolistic supplier of a specific labor input. The representative household, indexed by h, maximizes the expected intertemporal utility from consumption, $C_t(h)$, net of the disutility from supplying labor to intermediate goods producers, $L_t(h)$:

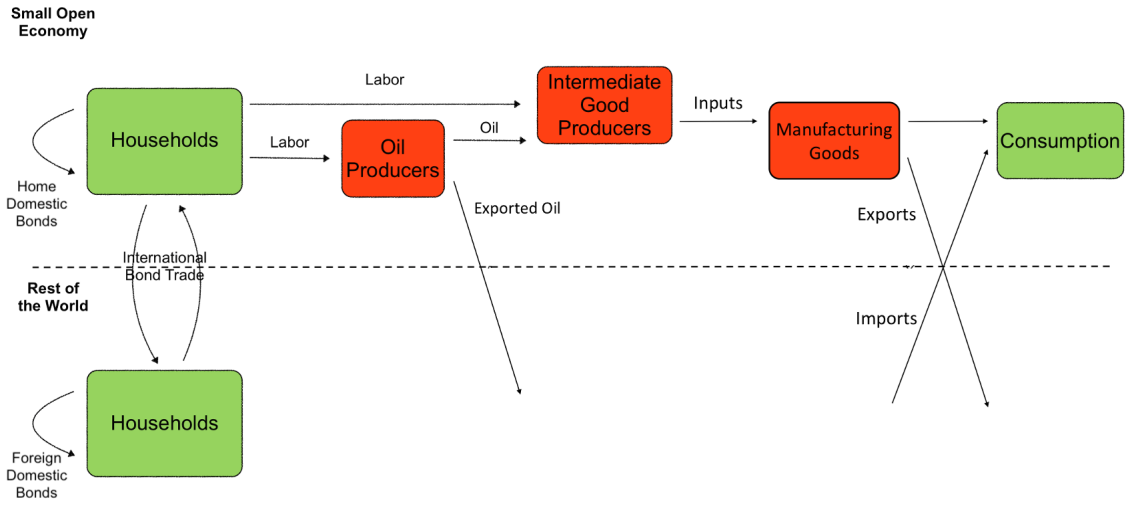
$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t(h), L_t(h)), \tag{1}$$

where $U(C_t(h), L_t(h)) = \frac{C_t(h)^{1-\gamma}-1}{1-\gamma} - \chi \frac{L_t(h)^{1+\varphi}}{1+\varphi}$, $\gamma, \chi, \varphi \geq 0$, and $\beta \in (0,1)$ is the discount factor.

The aggregate consumption is an Armington aggregator of domestically produced and imported manufacturing goods with elasticity of substitution $\omega > 0$:

$$C_t = \left(a_H^{1/\phi} C_{H,t}^{\frac{\phi-1}{\phi}} + (1-a_H)^{1/\phi} C_{F,t}^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}},$$

Figure 4: Model Architecture



with $0 < a_H < 1$. The aggregate price index is $P_t = \left(a_H P_{H,t}^{1-\phi} + (1-a_H)P_{F,t}^{1-\phi}\right)^{\frac{1}{1-\phi}}$. [2] Consumption of domestically produced manufacturing goods, $C_{H,t} = \left(\int_{\omega\in\Omega} C_{H,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega\right)^{\frac{\theta}{\theta-1}}$, represents an aggregate of Home consumption varieties over a continuum Ω. Similarly, $C_{F,t} = \left(\int_{\omega\in\Omega^*} C_{F,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega\right)^{\frac{\theta}{\theta-1}}$, represents the consumption bundle of the imported manufacturing goods. As in Corden and Neary (1982), only a subset of $\Omega_t \subset \Omega$ goods are available to consumer. Thus, the price index for the domestic consumption of domestically produced and imported manufacturing goods are $P_{H,t} = \left(\int_{\omega\in\Omega_t} P_{H,t}(\omega)^{1-\theta} d\omega\right)^{\frac{1}{1-\theta}}$ and $P_{F,t} = \left(\int_{\omega\in\Omega_t^*} P_{F,t}(\omega)^{1-\theta} d\omega\right)^{\frac{1}{1-\theta}}$, accordingly.

3.2 Firms

There are three types of firms in the economy: commodity goods producers, intermediate goods producers, and manufacturing goods producers. Intermediate goods producers combine labor with commodity goods to produce intermediate goods, and manufacturers use intermediate goods as inputs to produce the consumption good.

3.2.1 Intermediate Goods Producers

There is a continuum of perfectly competitive intermediate good producers that combine labor and

[2] We anticipate the symmetric equilibrium across individuals, and from here on, we drop the index h to simplify notation.

a commodity good to produce output:

$$Y_t^I = (Z_t L_t^I)^\alpha M_t^{1-\alpha},$$

where Z_t is exogenous aggregate productivity, L_t^I is a bundle of labor input supplied by households to the intermediate goods producers, and $M_t = M_{H,t} + M_F$ is total commodity good used in intermediate goods production. $M_{H,t}$ is commodity good purchased from domestic commodity producers and M_F is the amount of imported commodity good which is not responsive to fluctuations in the small open economy.[3]

The intermediate goods producers choose the amount of labor and commodity good to maximize their profits:

$$d_t^I \equiv \psi_t Y_t^I - w_t^I L_t^I - Q_t rp_{M.t}^*,$$

where ψ_t is the real price of the intermediate good, w_t^I is the real wage paid to laborers, and $rp_{M,t}^*$ is the relative price of the commodity good in foreign units and Q_t is the real exchange rate, $Q_t \equiv \frac{S_t P_t^*}{P_t}$, and S_t is the nominal exchange rate (Home price of one unit of Foreign currency).

3.2.2 Manufacturers

Manufacturing sector is composed of a continuum of monopolistically competitive firms, each producing a differentiated good variety. Each variety can be sold domestically and internationally. Manufacturers draw a productivity level z from a known distribution $G(z)$ with support $[z_{min},, \infty)$. There is an unbounded mass of entrants at every time period t and they are subject to a time-to-build condition as they can start producing only at $t+1$. Each firm faces a sunk entry cost $f_{E,t}$ in units of intermediate good and produces until it is hit by a death shock with probability $\delta \in (0,1)$ in every period. In each time period, there are $N_{D,t}$ producing firms, among which $N_{X,t}$ of them are exporters. Number of entrants is denoted by $N_{E,t}$. The law of motion for the number of producing firms is $N_{D,t+1} = (1-\delta)(N_{D,t} + N_{E,t})$.

Exporters face per-unit iceberg trade costs, $\tau_t > 1$, and fixed export costs, $f_{X,t}$, in units of intermediate good. Fixed export costs ensure that only firms which are above a threshold productivity

[3]This is in line with the evidence from Canada, as importers are clustered in specific regions, relatively small in size, and unresponsive to domestic oil production.

level are able to export.

Following Melitz (2003) and Ghironi and Melitz (2005), we define two an average productivity level for all firms, $\tilde{z}_D$, and an average productivity level for exporters, $\tilde{z}_{X,t}$:

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

Using average productivities, the model can be reformulated in terms of average representative firms. The assumption of z being drawn from a Pareto distribution with lower bound z_{min} and shape parameter $\kappa > \theta - 1$ implies the share of exporting firms can be represented as:

$$\frac{N_{X,t}}{N_{D,t}} = 1 - G(z_{X,t}) = \left(\frac{z_{min}}{\tilde{z}_{X,t}} \right)^{\kappa} \left(\frac{\kappa}{\kappa - \theta + 1} \right)^{\frac{\kappa}{\theta-1}}.$$

The nominal domestic price and export price set by producer z is denoted by $P_{H,t}(z)$ and $P^*_{H,t}(z)$. Exports are priced in the rest of the world currency. Prices are set by a constant markup, $\frac{\theta}{\theta-1}$, over marginal costs. Let $rp_{H,t}(z) \equiv \frac{P_{H,t}(z)}{P_t}$ and $rp^*_{H,t}(z) \equiv \frac{P^*_{H,t}(z)}{P^*_t}$ denote real prices. Monopolistic competition implies $rp_{H,t}(z) = \frac{\theta}{\theta-1}\frac{\psi_t}{z}$ and $rp^*_{H,t}(z) = (1+\tau_t)\frac{rp_{H,t}(z)}{Q_t}$.

The producer determines $N_{D,t+1}$ and the productivity cutoff $z_{X,t}$ to minimize its expected total discounted costs of production. The cost minimization problem leads:

$$\psi_t f_{E,t} = \mathbb{E}_0 \left[(1-\delta)\beta_{t,t+1} \left(\begin{array}{c} \psi_{t+1}(f_{E,t+1} - \frac{N_{X,t+1}}{N_{D,t+1}} f_{X,t+1}) \\ + \frac{1}{\theta-1} \left(\frac{\psi_{t+1}}{\tilde{z}_D} \frac{Y_{H,t+1}}{N_{D,t+1}} + \frac{\psi_{t+1}}{\tilde{z}_{X,t}} \frac{Y^*_{H,t}}{N_{X,t+1}} \frac{N_{X,t+1}}{N_{D,t+1}} \tau_{t+1} \right) \end{array} \right) \right],$$

$$\frac{\kappa - (\theta-1)}{(\theta-1)\kappa} \frac{\psi_t}{\tilde{z}_{X,t}} \frac{Y^*_{H,t}}{N_{X,t}} \tau_t = f_{X,t}\psi_t.$$

3.2.3 Commodity Producers

The commodity sector operates under a decreasing returns to scale technology and uses only labor as an input:

$$M_{H,t} + M^*_{H,t} = Z^O_t (L^O_t)^{\alpha_O},$$

where $M^*_{H,t}$ is the exported commodity good and $0 < \alpha_O < 1$.

Profit maximization leads to the following first-order condition:

$$\alpha_O Q_t rp^*_{M,t} Z^O_t (L^O_t)^{\alpha_O - 1} = w^O_t.$$

Given a wage rate in the commodity sector, an increase in the price of the commodity good leads to an increase in labor demand. The commodity good is sold at international prices and hence fluctuations in real exchange rate affect labor employed in the commodity sector. Given world commodity prices, an appreciation in the real exchange rate leads to a decrease in labor demand in commodity good production.

The real commodity price, $rp^*_{M,t}$, follows an AR(1) process:

$$log(rp^*_{M,t}) = (1 - \rho_{\rho_M}) log(rp^*_M) + \rho_{\rho_M} log(rp^*_{M,t-1}) + \epsilon_{\rho_M},$$

where $rp^*_M > 0$ is the steady-state value of the real commodity price, ρ_{ρ_M} is an autoregressive coefficient, and ϵ_{ρ_M} is a normally distributed shock with zero mean and unit variance.

3.3 Households

Households supply differentiated labor inputs, which gives them wage setting power. Intermediate good producers employ a Dixit-Stiglitz composite of labor inputs: $L^i_t \equiv \left[\int_0^1 L^i_t(h)^{\frac{\epsilon_W - 1}{\epsilon_W}} dh\right]^{\frac{\epsilon_W}{\epsilon_W - 1}}$ where $\epsilon_W > 1$ is the elasticity of substitution between the differentiated labor inputs and $i \in \{I, O\}$. The aggregate nominal wage index is $W^i_t \equiv \left[\int_0^1 W^i_t(h)^{1-\epsilon_W} dh\right]^{\frac{1}{1-\epsilon_W}}$, where $W^i_t(h)$ is the nominal wage set by household h. Optimal demand of labor input h is determined by:

$$L^i_t(h) = \left(\frac{W^i_t(h)}{W^i_t}\right)^{-\epsilon_W} L^i_t. \tag{2}$$

Household h sets the nominal wage $W_t(h)$ subject to (2) when maximizing utility. Wage setting is subject to a quadratic cost of adjusting the nominal wage rate between period $t-1$ and t as in Rotemberg (1982):

$$\frac{\kappa^{W^i}}{2} \left(\frac{W^i_t(h)}{W^i_{t-1}(h)} - 1\right)^2 W^i_t(h) L^i_t(h),$$

where $\kappa^W \geq 0$ determines the size of the adjustment cost (if $\kappa^W = 0$, then wages are flexible). The

size of this cost is proportional to labor income.

Each household can hold one-period non-contingent nominal bonds issued by other domestic and RoW households, B and B_*. The nominal exchange rate is denoted by S. International asset markets are incomplete, as only risk-free bonds are traded across countries . EME (RoW) bonds are issued by EME (RoW) households and denominated in EME (RoW) currency. Quadratic costs of adjusting bond holdings ensure that there is a unique steady state, characterized by zero international bond holdings; hence, the economy goes back to its initial position after temporary shocks. In equilibrium, these costs are rebated back to households in lump-sum fashion.

The period budget constraint of the household can be written as:

$$\begin{aligned} &P_t C_t(h) + B_{t+1}(h) + S_t B_{*,t+1}(h) + \tfrac{\eta}{2} S_t P_t^* (\tfrac{B_{*,t+1}(h)}{P_t^*})^2 + \tilde{e}_t (N_{D,t} + N_{E,t}) x_{t+1}(h) \\ &= R_t B_t(h) + S_t R_t^* B_{*,t}(h) + \textstyle\sum_{i \in \{I,O\}} \left[W_t^i(h) L_t^i(h) - \frac{\kappa^{W^i}}{2} \left(\frac{W_t^i(h)}{W_{t-1}^i(h)} - 1 \right)^2 W_t^i(h) L_t^i(h) \right] \\ &\qquad + (d_t + \tilde{e}_t) N_{D,t} x_t(h) + T_t(h), \end{aligned} \tag{3}$$

where $\frac{\eta}{2} \xi_t (B_{*,t+1})^2$ is the cost of adjusting holdings of internationally traded bonds (with $\eta > 0$), and $T_t(h)$ is its rebate, taken as given by the household. R_{t+1} and R_{t+1}^* are the gross nominal interest rates on EME and RoW bond holdings between t and $t+1$. Finally, d_t denotes profits from producers, and $\tilde{e}_t \equiv \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} \beta_{t,s} (1-\delta)^{s-t} \tilde{d}_s \right]$ is the entry decision based on the expected present discounted value of period average profits. Free-entry condition implies that entry occurs until the average firm value equals entry cost, that is $\tilde{e}_t = \psi_t f_{E,t}$.

The household maximizes (1) subject to (2), and (3). The Euler equations for bond holdings are as follows:

$$1 = R_{t+1} \mathbb{E}_t \left[\frac{\beta_{t,t+1}}{\Pi_{t+1}} \right], \tag{4}$$

$$1 + \eta b_{*t+1} = R_{t+1}^* \mathbb{E}_t \left[\frac{\beta_{t,t+1}}{\Pi_{t+1}^*} \frac{rer_{t+1}}{rer_t} \right], \tag{5}$$

where $\beta_{t,t+s} \equiv \frac{\beta U_{C,t+s}}{U_{C,t}}$ is the stochastic discount factor and $U_{C,t}$ denotes the marginal utility from consumption in period t. Π_t and Π_t^* denote gross inflation between $t-1$ and t in EME and RoW. $b_{t+1} \equiv \frac{B_{t+1}(h)}{P_t}$ and $b_{*t+1} \equiv \frac{B_{*,t+1}(h)}{P_t^*}$ are the real holdings of EME and RoW bonds. We omit the transversality conditions for bond holdings.

The Euler equations above imply the no-arbitrage condition:

$$\frac{R_{t+1}}{R^*_{t+1}} = \frac{(1+\eta b_{t+1})\mathbb{E}_t[\frac{\beta_{t,t+1}}{\Pi^*_{t+1}}\frac{rer_{t+1}}{rer_t}]}{(1+\eta b_{*,t+1})\mathbb{E}_t[\frac{\beta_{t,t+1}}{\Pi_{t+1}}]}.$$

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The first-order-condition with respect to $W^i_t(h)$ implies that the real wage, $w^i_t \equiv \frac{W^i_t}{P_t}$, is a time-varying markup over the marginal rate of substitution between labor and consumption:

$$w_t = \mu^W_t \left(\frac{\chi L^\varphi_t}{C^{-\gamma}_t}\right), \tag{6}$$

where we used the fact that $W^i_t(h) = W^i_t$ in the symmetric equilibrium, and $\mu^{W^i}_t$ is defined by:

$$\mu^{W^i}_t \equiv \frac{\epsilon_W}{(\epsilon_W - 1)\left(1 - \frac{\kappa^W}{2}(\Pi^{W^i}_t - 1)^2\right) + \kappa^W\left(\Pi^{W^i}_t(\Pi^{W^i}_t - 1) - \mathbb{E}_t\left[\frac{\beta_{t,t+1}}{\Pi_{t+1}}(\Pi^{W^i}_{t+1} - 1)(\Pi^{W^i}_{t+1})^2\frac{L^i_{t+1}}{L^i_t}\right]\right)},$$

with $\Pi^{W^i}_t \equiv \frac{w^i_t}{w^i_{t-1}}\Pi_t$ being the gross nominal wage inflation.

3.4 Monetary Policy

The central bank sets the nominal interest rate according to a Taylor rule that reacts to deviation of inflation from its target and displays an exogenous shock:

$$\frac{R_{t+1}}{R} = \left(\frac{R_t}{R}\right)^\rho \left(\frac{\Pi_t}{\Pi}\right)^{(1-\rho)\rho_\Pi} e^{u_t}, \tag{7}$$

where ρ is a smoothing parameter that captures gradual movements in interest rates, and the parameters ρ_Π and ρ_Y denote the responsiveness of the nominal interest rate to deviations of inflation and output from their steady-state values.

The monetary policy shock, u_t, follows an $AR(1)$ process:

$$u_t = \rho^u u_{t-1} + e^{\sigma^R}\varepsilon_t, \tag{8}$$

where ε_t is a normally distributed shock with zero mean and unit variance.

4 Model Calibration and Simulations

In this section, we calibrate the model and illustrate its dynamics, highlighting the role of interest rate uncertainty in the adjustment of external accounts.

4.1 Calibration

We calibrate the model with standard parameter values often used in the literature. This allows us to assess the implications of commodity price shocks without the risk of our findings being the product of an unusual calibration.

We set the discount factor, β to 0.99. Relative risk aversion, γ, relative weight of labor in the utility function, χ, and Frisch elasticity, φ, are also set to conventional values in the literature: 2, 1, and 1, respectively. We set the scale parameter for the costs of adjusting bond holdings, η, to 0.0025 as in Ghironi and Melitz (2005). This value implies that this adjustment cost has a negligible impact on model dynamics, other than pinning down the non-stochastic steady state and ensuring mean reversion when shocks are transitory. Following Barattieri et al. (2020), we set κ^W to 116 for nominal wage stickiness. Moreover, we set the elasticity of substitution between differentiated labor inputs, ϵ^W, to 11, which implies a wage markup of 10% under flexible wages.

For the parameters that are related to producer optimization, we set the elasticity of substitution of tradable varieties θ to 3.8. We follow the previous literature and assume that firm-level productivity z is drawn from a Pareto distribution with lower bound z_{min} and shape parameter $k > \theta - 1$. The fixed cost of exporting, f_X, is chosen such that in steady state 21 percent of firms export their good (Bernard et al., 2003).

Finally, our choice of parameters in the Taylor rule is also in line with the previous literature: We set the smoothing coefficient, ρ and the responsiveness to inflation, ρ_Π to 0.7 and 1.5, respectively.

4.2 Commodity Price Shocks and the Real Exchange Rate

We investigate the consequences of a one-percent decline in commodity prices. Figure 5 plots the impulse responses to the change in commodity prices.

Table 1: Calibration

Parameter		*Value*	*Comments*
Discount factor	β	0.99	Literature
Relative risk aversion	γ	2	Literature
Relative weight of labor in utility	χ	1	Literature
Frisch elasticity	φ	1	Literature
Bond adjustment	ψ	0.0025	Literature
Rotemberg wage adjustment	κ^W	116	Barattieri et al. (2018)
Elasticity of substitution of differentiated labor	ϵ^W	11	Wage markup of 10%
Fixed export costs	f_X	0.0865	21% of producers are exporters
Pareto shape parameter	k	3.4	Melitz (2003)
Iceberg trade cost	τ	0.3	Ghironi and Melitz (2005)
Rotemberg domestic price adjustment	κ	116	Barattieri et al. (2018)
Inverse elasticity of substitution between Home and Foreign goods	λ	1.5	Literature
Share of labor in oil production	α_O	0.66	Alberola and Benigno (2019)
Share of oil in mid-stream production	α	0.12	Resende, Dib, and Kichian (2010)
Interest rate smoothing coefficient	ρ_R	0.7	Literature
Steady state response to inflation	ρ_Π	1.5	Literature

Following an increase in commodity prices, inputs become more expensive for midstream producers and the price of their good goes up. The latter implies that marginal costs of manufacturers in the downstream production rise. The upward pressure in marginal costs attenuates entry, as the present discounted value of their expected stream of profits decrease. The number of producers in the small open economy decreases, the average productivity is higher than the pre-shock level.

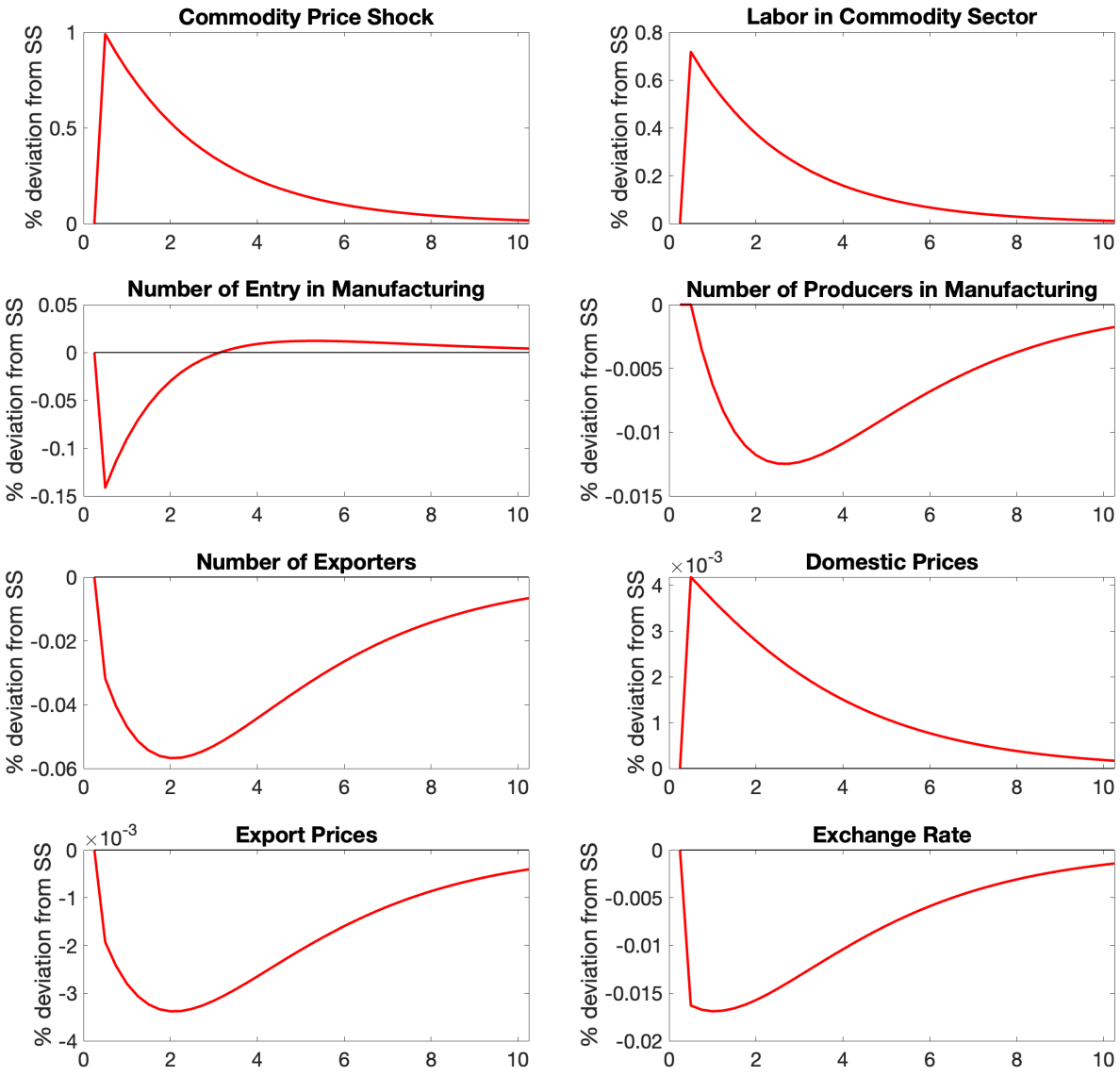
Higher exporter productivity implies lower prices for the exported manufacturing goods. When export prices are sticky in the rest of the world currency, this implies an appreciation in the exchange rate. As seen in Figure 5, the response of export prices is small, in comparison to fluctuation in exchange rates. Importantly, our mechanism implies a causality from export prices to the exchange rate. Unlike in the models without extensive margin dynamics, we observe a meaningful correlation between the export prices and the exchange rate under dominant currency pricing of exports.

To provide more intuition for our result, we rewrite the exchange rate using price indices. Following Ghironi and Melitz (2005), we obtain a data-consistent price index, $\tilde{P}_t$, that eliminates the variety effect from the welfare-consistent price index, P_t. To do so, we define $P_t = \Delta_t^{1/(1-\phi)}\tilde{P}_t$, where $\Delta_t \equiv a_H N_{D,t}^{\frac{1-\phi}{1-\theta}} + (1-a_H)N_{X,t}^{*\frac{1-\phi}{1-\theta}}$. Hence, we can define $\tilde{Q}_t \equiv \frac{S_t\tilde{P}_t^*}{\tilde{P}_t}$ as the theoretical counterpart to the empirical real exchange rate. Using the definitions of price indices it is straightforward to obtain:

$$\tilde{Q}_t^{\,1-\phi} = \frac{a_H \frac{N_{D,t}^{*\frac{1-\phi}{1-\theta}}}{\Delta_t^*}\left(\frac{S_t^{1-\alpha}W_{F,t}^{*1-\alpha}}{W_{H,t}^{1-\alpha}}\right)^{1-\phi} + (1-a_H)\frac{N_{X,t}^{\frac{1-\phi}{1-\theta}}}{\Delta_t^*}\left(\tau_t\frac{\tilde{z}_D}{\tilde{z}_{X,t}}\right)^{1-\phi}}{a_H\frac{N_{D,t}^{\frac{1-\phi}{1-\theta}}}{\Delta_t} + (1-a_H)\frac{N_{X,t}^{*\frac{1-\phi}{1-\theta}}}{\Delta_t}\left(\frac{S_t^{1-\alpha}W_{F,t}^{*1-\alpha}}{W_{H,t}^{1-\alpha}}\tau_t^*\frac{\tilde{z}_D}{\tilde{z}_{X,t}^*}\right)^{1-\phi}}. \tag{9}$$

Equation (9) is useful in understanding how sectoral dynamics are at place in generating the exchange rate depreciation in response to a fall in commodity prices. Following a negative commodity price shock, labor demand in the commodity producing sector goes down and wages decline. This also implies that the cost of intermediate good production is cheaper and intermediate good producers demand more inputs, including labor. Labor reallocates from commodity producing sector to intermediate good producing sector. This is being reflected as an increase in the wages offered by intermediate good producers. Defining $TOL_t \equiv \frac{S_t^{1-\alpha}W_{F,t}^{*1-\alpha}}{W_{H,t}^{1-\alpha}}$ as the "terms of labor," we can measure the relative cost of effective units of labor across countries. We see from the denominator of the equation above that, combined with the variety effects, an increase in the relative cost of labor in

Figure 5: Effects of a Commodity Price Shock



intermediate good production is linked with the depreciation of the currency.

5 Welfare Analysis

Having explored the transmission and propagation mechanisms of commodity price shocks, we now evaluate its performance in the baseline model in terms of a consumption compensating variation metric. We compare inflation targeting with a fixed exchange rate regime. We compare two regimes in terms of the compensating variation—the percentage of consumption that must be altered under inflation targeting to generate the same welfare as under fixed exchange rate regime.

Welfare Comparison

When calculating welfare, it is important to determine whether a conditional or unconditional metric is used, and whether calculations are made when the steady state is efficient or inefficient. The unconditional metric measures welfare as the unconditional expectation of the value of the utility function and abstracts from the transition costs when policies are in effect. Hence, we focus more on the conditional metric—conditioned on the value of the non-stochastic steady state—in accounting for the transitional costs when policies are in place.

Since our exercise was motivated by a clearly non-cooperative interaction of the small open economy with the rest of the world, neither of the policies we consider is introduced from the perspective of a global policymaker (or social planner) to introduce perfect risk sharing in international financial markets. Hence, when evaluating welfare, we focus only on the small open economy lifetime utility and simulations are from the inefficient steady state.

We calculate the conditional compensating variation as follows. Let us denote the expected present discounted value of utility under each policy option as follows:

$$V_t^i = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left(\frac{{C_{t+j}^i}^{1-\rho} - 1}{1-\rho} - \chi \frac{{L_{t+j}^i}^{1+\varphi}}{1+\varphi} \right) \qquad i \in \{IT, PEG\}.$$

Define λ as the percentage of consumption the representative EME household needs for each period

Table 2: Welfare

	Welfare under IT	*Welfare under PEG*	*Welfare Cost, λ*
Conditional	-128.912	-95.685	0.0311
Unconditional	-290.4578	-128.664	0.0180

during which IRUPT is in place in order to have the same lifetime utility as when CCU is in place:

$$V_t^{PEG} = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \frac{\left((1+\lambda)C_{t+j}^{IT}\right)^{1-\rho} - 1}{1-\rho} - \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \chi \frac{L_{t+j}^{IT\ 1+\varphi}}{1+\varphi}.$$

In this equation, the value functions are conditional on the same point. We calculate the unconditional metric by simulating the model with commodity price shocks for 4,000 periods, starting from the non-stochastic steady state and taking the average of the simulations.

Table 2 shows the compensating variation in consumption for both the conditional and unconditional metrics. The unconditional compensating variation shows that, in order to live under the fixed exchange rate regime, households desire a level of consumption that is about 1.8 percent higher the level of consumption under inflation targeting regime. However, when transition effects are calculated, inflation targeting performs much better than fixed exchange rate regime. Households need a level of consumption under the fixed exchange regime that is almost 3 percent higher than the level of consumption under inflation targeting. The main reason is that under inflation targeting the welfare loss from fluctuations in labor wedges are much smaller.

6 Conclusions

In this paper, we investigated the effects of inflation targeting and flexible exchange rates on mitigating the impact of commodity price shocks. Our empirical findings demonstrate that the adoption of inflation targeting significantly dampens the negative effects of such shocks on the manufacturing sector. This suggests the presence of a strong expenditure-switching channel, even in cases where exports are invoiced in U.S. dollars, highlighting the importance of the exchange rate's role in adjusting the economy.

To further explore these results, we developed a theoretical model incorporating international trade, firm heterogeneity, endogenous firm selection into trade, and nominal rigidity. The model reveals that increases in commodity prices elevate marginal production costs, which in turn slow down producer entry into the market. This dynamic change in the composition of producers alters the average productivity in the manufacturing sector, ultimately leading to lower prices. We find that when export prices are sticky in a dominant currency, a flexible exchange rate can still appreciate, thereby insulating the economy from external shocks.

Our model successfully reproduces the observed high correlation between export price indices and exchange rates, even in countries whose exports are priced in U.S. dollars. Inflation targeting combined with flexible exchange rates enhances welfare compared to alternative monetary regimes. The extensive margin dynamics we outline underscore the importance of flexible exchange rates in buffering commodity price shocks, thereby improving macroeconomic stability. Further research could explore the benefits of flexible exchange rates under state dependent pricing.

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