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Structural Reforms in DSGE Model

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Abstract

This paper develops a DSGE model for a small open economy dividing it into tradable and non-tradable sectors in order to evaluate the impact of structural reforms on the economy for developing countries. The model is constructed and solved in a way that the steady state level of each sector's employment rate is a function of its sector subsidy level. The economic meaning of such a result is that when a government subsidizes one of the sectors can become over employed. We also discuss the effects of exchange rate depreciation as an unconventional monetary policy tool when there is a ZLB problem or as a tool to boost the economy and to improve the current account. The results show that directly subsidizing the tradable sector can be a better policy than the depreciation of nominal exchange rate for making the economy more export oriented. The reason of such outcomes is the price stickiness of the sectors, which was validated by checking the sensitivity of the model with respect to its structural parameters. To conclude, for closing current account deficit or simply, for improving it the government should implement policies aimed at changing the structure of the economy.

JEL classification:E12, E37, E52, E65, F31, H25
Keywords: small open economy, DSGE, monetary policy, taxes and subsidies, foreign exchange

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Contents

1 Introduction

Structural reforms are essentially measures that change the fabric of an economy, the institutional and regulatory framework in which businesses and people operate. They are designed to ensure the economy is fit and better able to realise its growth potential in a balanced way[1].

Thus, structural reforms are the policies designed for improving the economic performance of the country. The variety of such policies is big they include regulations in goods and product markets, trade liberalization, developing financial and capital markets as well as infrastructures and so on.

This paper investigates the effects of structural reforms that are being or have been taken in many emerging economies, particularly, the reforms of goods market. For this purpose, we separate different industries into two sectors depending on some essential characteristics, namely, on the level of productivity and their participation in international trade. Policy maker implements different strategies to boost more productive sectors, more formally, the government directly affects the marginal costs of different industries by increasing or reducing sectoral tax rates. Such policy forces less productive firms of particular sector to exit the market and eventually the economy gets to a new equilibrium with more efficient resource allocation, especially, in terms of labor force.

In this paper, we examine the effect of sectoral producer tax/subsidy on the allocation of labor resources. In an equilibrium the privileges that firms get from the government, including tax benefits or anything that would imply lower marginal cost, stimulate them to increase their production by hiring more labor force.

We show that there is a positive link between the employment rate and the level of subsidy for each sector. This finding is supported both empirically and theoretically. Holmlund and Kolm (2002) using the two sector model show that the demand for labor in the non-tradable sector is a decreasing function of VAT taxes and they claim that the same result can be obtained using payroll taxes. Kugler and Kugler (2009) using a panel data for manufacturing plants in Columbia show that higher payroll taxes reduce the employment rate.

The second part of the paper is depicted the exchange rate policies. For a policy maker it is important to get some insights about how exchange rate depreciation as an unconventional monetary policy tool can boost the economy and what effects will this policy have in a relatively long-term depending on the structure of the economy.

First, we incorporate time-varying subsidies and mark-ups similar to Christiano et al. (2011) and Adolfson et al. (2007). These two processes are assumed to fluctuate around their steady state values over time. The steady state value of each sector mark-up is determined from the degree of competition of that sector and the subsidy is something, which is given from the government to firms and changes their marginal costs. The steady state block of model is solved in a way that the steady state value of each sector's employment is a function of

[1]The definition given by European Central Bank

its corresponding subsidy level along with other structural parameters. Therefore, to simulate a structural reform we increase or decrease the level of subsidy of one sector and examine the transition dynamics of reaching the new steady state of all relevant variables from the old one. To get these results the model is written in level form, otherwise in the case of a log-linearized modelthe steady state values of all variables are equal to zero without a possibility to change them.

For examining the exchange rate depreciation as a monetary policy tool, (this policy can be viewed both as an unconventional policy tool in case of zero lower bond (ZLB) and as a tool to boost the exports by improving the trade balance) we simulate a prolonged risk premium shock and depict the response of the economy. In addition, we examine the same shock for alternative scenarios by changing the price stickiness of the sectors. Subsequently, we will see that these parameters play a crucial role in assessing the long-run effects of such a policy. The sensitivity analysis is also done for other structural parameters.

The model's structural parameters are calibrated using the most common values that appear in literature. Since the key parameters in our model are the price stickiness of tradable and non-tradable sectors, we examine the papers, which have estimated these parameters for developing countries (Czech Republic, Romania, Poland, Russia). The main inference is that the price of non-tradable sector is much stickier than the price of tradable sector. The rest of sectoral parameters are set equal to each other in our baseline model in order to draw stronger conclusions.

The remainder of the paper is organized as follows. Section 2 reviews the literature related to the research topic. In Section 3, the theoretical model is derived and described with a particular emphasis on its steady state aspects. In Section 4, we analyse the transition dynamics of structural reforms and discuss the exchange rate policy issues. The last section provides some conclusions.

2 Literature Review

Dividing small open economies into tradable and non-tradable sectors to examine the effects of various shocks is a widely accepted approach. One of the foremost prominent researches within this framework is the theory of the tradable and non-tradable determinants of inflation (Balassa (1964), Samuelson (1964)). The Balassa-Samuelson hypothesis states that inflation of the non-tradable sector relative to tradable sector inflation should be inversely related to relative productivity growth.

Betts and Kehoe (2006) discuss the respective importance of the internal exchange rate (i.e. the prices of non-tradables to tradables) in explaining fluctuations in the overall exchange rate.

Obstfeld and Rogoff (2007) explore the likely real exchange rate changes needed to unwind the US current account deficit and point to a potentially large role for non-tradable prices. A reduction of the current account deficit requires a large cut in the US consumption of tradable goods. If the US economy is to avoid serious distortions, this requires a fall in the relative price of non-tradables.

Rodrik (2008) shows that developing countries that systematically undervalue their currencies in real terms grow faster than their counterparts. This is because undervaluation raises the rate of return to capital employed in the production of tradable goods by an amount sufficient to overcome the wide range of institutional problems that disproportionately affect that sector of the economy. However, this strategy is only second-best in the context of the economic distortions discussed in his paper. The first-best strategy is eliminating the institutional and market failures. A more practical approach is to subsidize tradables production directly, rather than indirectly through the real exchange rate. Real undervaluation is equivalent to a production subsidy plus a consumption tax on tradables.

Roeger et al. (2008) analyse the costs and benefits of reforms in Europe by constructing a DSGE model with endogenous growth and defining 9 scenarios of reforms, including reduction of product/labor markets mark-ups and capital costs as well as improvement of human capital. Their results show that the reforms have beneficial effects on output and employment.

Campos and Kinoshita (2010) examine the relationship between structural reforms and foreign direct investment (FDI) inflows. They use a large yearly panel of developing economies for the period from 1989-2004. The main finding is that of a strong positive relationship of reforms to FDI.

Aghion et al. (2012) argues that sectoral policies aimed at targeting production activities of a particular sector, can enhance growth and efficiency if they are made competition-friendly. Their empirical results suggest that if subsidies are allocated to competitive sectors or allocated in such a way as to preserve or increase competition, then the net impacts of subsidies on TFP levels or growth become positive and significant.

Vogel (2014) using the QUEST III model analyses the question whether nontradable (service) sector reform would reduce external imbalances in monetary union, notably from the side of surplus countries. It considers an open economy with a positive net foreign asset (net creditor) position and shows that tradable and nontradable sector reforms, understood as reforms that shift the supply curve in the respective sector outward, tend to have similar external balance effects. Namely, supply-side reforms improve the price competitiveness of domestic output and tend to increase the trade and current account balance on impact. In the longer term, competitiveness gains are compensated by additional imports associated with domestic income growth.

In the context of currency regime, it is rarely discussed as one of the major determinants of output (income), though in theory, there have been a few mechanisms through which ERs are thought to affect growth (Miles, 2006). For instance, Levy-Yeyati and Sturzenegger (2003) show that floating rates lead to increased growth for a sample of emerging market countries. Another study (Gosh et al., 2003), however, believes that the ER arrangement (regime) does not matter for growth, but the RER is absolutely crucial for economic growth.

Finally, the discussion of structural reforms as one of the main determinants in promoting the long-run growth potential of the economy for developing countries has got not as much attention as one might expect. Micallef (2013) discuss the reforms of Maltese economy constructing a EAGLE model, which is the extension of a DSGE model. In his work Micallef shows that for the Maltese economy a 10% point reduction in services and labor markups (structural reform) raises GDP by more than 5% in the long-run. However, his approach in modelling the structural reforms might have some issues that we try to eliminate. First, to obtain proper estimates of mark-ups (the change of mark-ups is used to simulate structural reforms) of the economy for different sectors is not always possible, especially, for developing countries, where there is a lack of micro data. Second, mark-ups are determined in the market and the government cannot directly affect this parameter. To overcome this problem, we implemented subsidies in the model, which are assumed to be the policy tool and can be changed directly by the government.

The novelty of this work is the discussing exchange rate shocks using a DSGE model assuming that markups defined for both tradable and non-tradable sectors as well as for importing sector to be time-varying stochastic processes (see for instance Adolfson et al. (2007)). We also incorporated time-varying subsidies in our model similar to Stork (2011) (from the view of monetary policy subsidies can be defined as taxes in minus sign), for our analysis we define one overall subsidy for each sector.

3 Model

We setup a basic New keynesian small open economy model as proposed by Gali and Monacelli (2005). Our model includes tradable and non-tradable sectors similar to model of Selaive and Tuesta (2006). However, unlike them, we define the markups of each sector independently by allowing them to vary over time. For policy analysis (implementing different policies) we also include time-varying subsidies.

3.1 Households

Consumption basket of a representative household consists of tradable and non-tradable goods. The consumption index is represented by the following constant elasticity of substitution function:

$$C_t \equiv \left[(1-\gamma_1)^{\frac{1}{\eta_1}}(C_{T,t})^{\frac{\eta_1-1}{\eta_1}} + \gamma_1^{\frac{1}{\eta_1}}(C_{N,t})^{\frac{\eta_1-1}{\eta_1}}\right]^{\frac{\eta_1}{\eta_1-1}} \tag{3.1.1}$$

where $C_{T,t}$ is consumption of tradable goods, $C_{N,t}$ is consumption of non-tradable goods, η_1 is the elasticity of substitution between these two types of goods goods and γ_1 is the share of non-tradable goods in a consumption basket. By maximizing (3.1.1) subject to the budget constraint $P_{T,t}C_{T,t} + P_{N,t}C_{N,t} = P_tC_t$, we obtain the following consumption demand functions:

$$C_{T,t} = (1-\gamma_1)\left(\frac{P_{T,t}}{P_t}\right)^{-\eta_1} C_t, \tag{3.1.2}$$

$$C_{N,t} = \gamma_1\left(\frac{P_{N,t}}{P_t}\right)^{-\eta_1} C_t \tag{3.1.3}$$

From (3.1.2) and (3.1.3) we see that demands for both tradable and non-tradable goods are decreasing functions with respect to their relative price. The CPI (defined as the minimum expenditure required to buy one unit of C_t) is given by

$$P_t = \left[(1-\gamma_1)P_{T,t}^{1-\eta_1} + \gamma_1 P_{N,t}^{1-\eta_1}\right]^{\frac{1}{1-\eta_1}}, \tag{3.1.4}$$

where $P_{T,t}$ is aggregate price index of tradable goods and $P_{N,t}$ is aggregate price index of non-tradable goods.
Consumption of tradable goods is given by a composite consumption index

$$C_{T,t} = \left[(1-\gamma_2)^{\frac{1}{\eta_2}}(C_{H,t})^{\frac{\eta_2-1}{\eta_2}} + \gamma_2^{\frac{1}{\eta_2}}(C_{F,t})^{\frac{\eta_2-1}{\eta_2}}\right]^{\frac{\eta_2}{\eta_2-1}} \tag{3.1.5}$$

where $C_{H,t}$ and $C_{F,t}$ are respectively consumption of home produced and imported tradable goods, γ_2 is the share of imported goods in overall consumption of tradable goods, η_2 is the elasticity of substitution between imported and home produced tradable goods. Demand functions for home produced tradable and imported goods are derived by maximizing (3.1.5) subject to the budget constraint $P_{H,t}C_{H,t} + P_{F,t}C_{F,t} = P_{T,t}C_{T,t}$. They take the following forms

$$C_{H,t} = (1-\gamma_2)\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\eta_2} C_{T,t}, \tag{3.1.6}$$

$$C_{F,t} = \gamma_2\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\eta_2} C_{T,t} \tag{3.1.7}$$

where the price index for tradable goods (defined as the minimum expenditure required to buy one unit of $C_{T,t}$) is given by

$$P_{T,t} = \left[(1-\gamma_2)P_{H,t}^{1-\eta_2} + \gamma_2 P_{F,t}^{1-\eta_2}\right]^{\frac{1}{1-\eta_2}}, \tag{3.1.8}$$

where $P_{H,t}$ and $P_{F,t}$ are aggregate price indices for domestic and imported tradable goods respectively.

A typical small open economy is inhabited by a representative household who seeks to maximize the following utility function

$$E_t \sum_{j=0}^{\infty} \beta^j \left(\log(C_{t+j} - hC_{t+j-1}) - \chi_1 \frac{N_{N,(t+j)}^{1+\varphi_1}}{1+\varphi_1} - \chi_2 \frac{N_{H,(t+j)}^{1+\varphi_2}}{1+\varphi_2} \right) \tag{3.1.9}$$

where E_t is the expectation operator conditional on information available at time t, β is the discount factor, C_t is a composite consumption, $N_{H,t}$ and $N_{T,t}$ are working hours in non-tradable and tradable sectors respectively, φ_1 and φ_2 are the inverses of the Frisch elasticity of labor supply and χ_1 and χ_2 are the disutilities from working. Separating the labor in utility function represents the assumption that the labor market is not perfect and households should choose in which sector to work. Finally, we allow for habit persistence by including hC_{t+j-1}. Including habit in utility function is a common technique (see, for example, Adolfson et al. (2007)) to make consumption more persistent compared to output, which is observed empirically. The second motive for introducing habit into the model is to make consumption to be a lagged state variable. The parameter $h \in (0,1)$ denotes the intensity of habit formation and introduces non separability of preferences over time. Under habit persistence, an increase in current consumption lowers the marginal utility of consumption in the current period and increases it in the next period. In this sense, this type of preferences capture the notion of habit formation.

A household maximizes the utility function subject to the following budget constraint:

$$\begin{aligned} C_t + \frac{B_t}{P_t} + \frac{Ex_t B_T^*}{P_t} = \frac{W_{N,t}N_{N,t}}{P_t} + \frac{W_{H,t}N_{H,t}}{P_t} + \frac{R_{t-1}B_{t-1}}{P_t} + \\ + \frac{R_{t-1}^* Ex_t B_{t-1}^* \varepsilon_{prem,t-1}}{P_t} + \frac{Div_t}{P_t} \end{aligned} \tag{3.1.10}$$

where B_t and B_t^* are domestic and foreign one period, nominally riskless bonds held by the home economy's households between time t and $t+1$, R_t and R_t^* are the corresponding gross interest rates, Ex_t is the nominal exchange rate defined as the home currency per unit of foreign currency, $W_{N,t}$ and $W_{T,t}$ are corresponding nominal wage rates for non-tradable and tradable sectors, P_t is the consumer price index, $\varepsilon_{prem,t}$ is a risk premium and Div_t are dividends of firms, which are owned by households.

By maximizing (3.1.9) subject to (3.1.10), we get the following first order conditions:

$$C_t : \quad \frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t} - \lambda_t = 0 \tag{3.1.11}$$

$$N_{N,t} : \quad \lambda_t \frac{W_{N,t}}{P_t} = \chi_1 N_{N,t}^{\varphi_1} \tag{3.1.12}$$

$$N_{H,t} : \quad \lambda_t \frac{W_{H,t}}{P_t} = \chi_2 N_{H,t}^{\varphi_2} \tag{3.1.13}$$

$$B_t : \quad \beta E_t \left\{ \lambda_{t+1} \frac{R_t}{P_{t+1}} \right\} - \frac{\lambda_t}{P_t} = 0 \tag{3.1.14}$$

$$B_t^* \quad \beta E_T \left\{ \lambda_{t+1} \frac{R_t^* Ex_{t+1} \varepsilon_{prem,t}}{P_{t+1}} \right\} - \frac{\lambda_t Ex_t}{P_t} = 0 \tag{3.1.15}$$

Substituting λ_t by $\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}$ in equations (3.1.12) and (3.1.13) we get labor supply eqations for non-tradable and tradable sectors

$$\frac{W_{N,t}}{P_t} = \chi_1 N_{N,t}^{\varphi_1} \frac{(C_t - hC_{t-1})(C_{t+1} - hC_t)}{C_{t+1} - hC_t - \beta h(C_t - hC_{t-1})}, \tag{3.1.16}$$

$$\frac{W_{H,t}}{P_t} = \chi_2 N_{H,t}^{\varphi_2} \frac{(C_t - hC_{t-1})(C_{t+1} - hC_t)}{C_{t+1} - hC_t - \beta h(C_t - hC_{t-1})}. \tag{3.1.17}$$

Equations (3.1.16) and (3.1.17) state that the optimal labor-leisure choice requires that the marginal rate of substitution between consumption and hours worked (leisure) be equal the real wage.

Combining (3.1.11) and (3.1.14), we get the intertemporal consumption equation (Euler equation)

$$\beta R_t E_t \left\{ \frac{(C_{t+2} - hC_{t+1} - \beta h(C_{t+1} - hC_t))(C_t - hC_{t-1})}{(C_{t+1} - hC_t - \beta h(C_t - hC_{t-1}))(C_{t+2} - hC_{t+1})} \frac{P_t}{P_{t+1}} \right\} = 1. \tag{3.1.18}$$

Uncovered interest rate parity equation is derived by combining (3.1.14) and (3.1.15) conditions

$$R_t = E_t \left\{ \frac{Ex_{t+1}}{Ex_t} \right\} R_t^* \varepsilon_{prem,t} \tag{3.1.19}$$

It shows that differences in interest rates are a result of expected change of nominal exchange rate and country specific risk premium.

3.2 Law of one price gap, real exchange rate and terms of trade

The bilateral terms of trade are defined as the ratio of home produced and imported goods prices.

$$S_{i,t} = \frac{P_{H,t}}{P_{i,t}}. \tag{3.2.1}$$

The effective terms of trade are defined as

$$S_t \equiv \frac{P_{H,t}}{P_{F,t}}. \tag{3.2.2}$$

Law of one price (LOP) gap means that the law of one price fails to hold. It is given by the ratio of the foreign price index in terms of domestic currency and the domestic currency price of import

$$\Psi_t = \frac{Ex_t P_t^*}{P_{F,t}}, \tag{3.2.3}$$

where P_t^* is the price index of the rest of the world.

The real exchange rate is defined as

$$Q_t = \frac{Ex_t P_t^*}{P_t} \tag{3.2.4}$$

Internal exchange rate is defined by the ratio of prices on non-tradable good and home produced tradable good

$$S_{I,t} = \frac{P_{N,t}}{P_{H,t}}. \tag{3.2.5}$$

3.3 International risk sharing

Under the assumption of complete financial markets, the Euler equation must hold also for any other country

$$\beta R_t^* E_t \left\{ \frac{C_t^*}{C_{t+1}^*} \frac{P_t^*}{P_{t+1}^*} \right\} = 1 \tag{3.3.1}$$

Combining expression (3.3.1) with (3.1.18) and using the definition of real exchange rate, we get

$$C_t = \nu C_t^* Q_t \tag{3.3.2}$$

where ν is a constant depending on initial conditions. The assumption of complete financial markets is used to close the model (see Schmitt-Grohe et al. (2003)).

The home economy is small relative to the rest of the world and cannot impact on it. The external world is closed economy, hence the following condition should hold

$$Y_t^* = C_t^*.$$

3.4 Domestic producers of tradable and non-tradable goods

Domestic firms produce either tradable or non-tradable goods. In each group, there is a continuum of monopolistically competitive firms indexed $i \in [0,1]$. Each firm i produces differentiated goods, using the following Cobb-Douglas production function

$$Y_{j,t}(i) = A_{j,t} N_{j,t}^{(1-\alpha_j)}(i) \tag{3.4.1}$$

where the subscript $j = \{N, H\}$ is used to describe the decision problem of firms producing non-tradables (N) and tradables (H) respectively. $A_{j,t}$ is a productivity level, which follows the first order autoregressive process, and $(1-\alpha_j)$ is a share of labor in total resources. The usage of labor is lower in tradable sector compared to non-tradable one ($\alpha_H > \alpha_N$), as tradable sector is usually a more capital intensive branch of the economy.
The production function of the final good firm takes the form

$$Y_{j,t} = \left[\int_0^1 Y_{j,t}^{\frac{1}{\lambda_{j,t}}}(i) di \right]^{\lambda_{j,t}}, 1 \leq \lambda_{j,t} \leq \infty \tag{3.4.2}$$

where $\lambda_{j,t}$ is a stochastic process determining the time-varying markup in the domestic goods market. This process is assumed to follow

$$\lambda_{j,t} = (1-\rho_{\lambda_j})\lambda_j + \rho_{\lambda_j}\lambda_{j,t-1} + \varepsilon_{\lambda_j,t} \quad j = \{H, N\}$$

where, λ_j is the steady state value of corresponding mark-up. A final good firm takes its output price, $P_{j,t}$ and its input prices $P_{j,t}(i)$ as given. Profit maximization leads to the following first order condition

$$Y_{j,t}(i) = \left(\frac{P_{j,t}}{P_{j,t}(i)} \right)^{\frac{\lambda_{j,t}}{\lambda_{j,t}-1}} Y_{j,t}, \tag{3.4.3}$$

where demand for the i-th good is a function of relative prices. Firms in both sectors solve cost minimization problems of the forms

$$min \left\{ \frac{W_{H,t} N_{H,t}(1-\tau_{H,t})}{P_{H,t}} \right\}, \tag{3.4.4}$$

$$min \left\{ \frac{W_{N,t} N_{N,t}(1-\tau_{N,t})}{P_{N,t}} \right\}, \tag{3.4.5}$$

Solution of the above optimization problems gives marginal cost equations

$$MC_{H,t} = \frac{W_{H,t}(N_{H,t})^{\alpha_H}(1-\tau_{H,t})}{(1-\alpha_H) P_{H,t} A_{H,t}} \tag{3.4.6}$$

$$MC_{N,t} = \frac{W_{N,t}(N_{N,t})^{\alpha_N}(1-\tau_{N,t})}{(1-\alpha_N) P_{N,t} A_{N,t}}, \tag{3.4.7}$$

where $\tau_{i,t}$ is the rate of subsidy that firms get from the government, it follows an AR(1) process:

$$\tau_{j,t} = (1-\rho_{\tau_j})\tau_j + \rho_{\tau_j}\tau_{j,t-1} + \varepsilon_{\tau_j,t} \quad j = \{H, N\}.$$

(3.4.6) and (3.4.7) equations show that marginal cost in each sector is an increasing function of wages and labor input. Marginal cost is decreasing function with respect to the sector's specific price, technology and subsidy level. It also should be mentioned that $(1-\tau_t)$, together with λ_t, determines a firm's mark-up level.

We include subsidies (subsidies are assumed to be the same as taxes in a minus sign) in our marginal cost equations to account for tax effects and other privileges that firms can get from the government. Including subsidies in marginal cost equation we assume that subsidies have marginal effect on the producers income. In the log-linear version of the model in which there are no price distortions and which is used for estimation, $\tau_{j,t}$ is isomorphic to a disturbance in $\lambda_{j,t}$, i.e., a markup shock. The main purpose of including subsidies is to simulate permanent structural changes in two sectors by changing the steady state value of subsidies.

3.4.1 Price setting

We assume that domestic firms set prices in a staggered fashion à la Calvo (1983). Each period, a measure $1-\theta_j \quad j = \{N, H\}$ of (randomly selected) firms set optimally new prices. The remaining θ_j firms keep their prices unchanged. The average duration of a price is given by $\frac{1}{1-\theta_j}$. The probability that a firm re-optimizes its price is independent of the time elapsed since the last price adjustment. The parameter θ is a measure of the degree of nominal rigidity i.e. the larger θ the fewer the firms that adjust their prices each period and the longer the expected time between price changes.

Let $P^*_{j,t}(i)$ be the price set by a firm adjusting its price in period t. Note that for firms operating in tradable sector the price is $P_{H,t}$ and not $P_{T,t}$. Under the Calvo price setting, $P^*_{j,t+k}(i) = P^*_{j,t}(i)$ with probability θ_j^k for $k = 0, 1, 2, ...$ For convenience, we drop the i subscript since all re-optimizing firms will choose the same price.

A typical firm maximizes its profit function

$$\max_{P^*_{j,t}} \sum_{k=0}^{\infty} (\beta\theta_j)^k E_t \left[\Lambda_{t,t+k} \left(\frac{P^*_{j,t}}{P_{j,t+k}} - MC_{j,t+k} \right) Y_{j,t+k}(i) \right], \tag{3.4.8}$$

where $\beta^k \Lambda_{t,t+k} = \beta^k \left(\frac{U_{c,t+k}}{U_{c,t}} \right)^{-1} \frac{P_t}{P_{t+k}}$ is the stochastic discount factor.

From (3.4.3) we have

$$Y_{j,t+k}(i) = \left(\frac{P^*_{j,t}}{P_{j,t+k}} \right)^{-\frac{\lambda_{j,t+k}}{\lambda_{j,t+k}-1}} Y_{j,t+k} \tag{3.4.9}$$

Solving (3.4.8), we find the optimal price $P_{j,t}$ for both sectors

$$P^*_{j,t} = \lambda_{j,t} \frac{E_t \sum_{k=0}^{\infty} (\theta_j \beta)^k \Lambda_{t,t+k} Y_{j,t+k} P_{j,t+k}^{\frac{\lambda_{j,t+k}}{\lambda_{j,t+k}-1}} MC_{j,t+k}}{E_t \sum_{k=0}^{\infty} (\theta_j \beta)^k \Lambda_{t,t+k} Y_{j,t+k} P_{j,t+k}^{\frac{1}{\lambda_{j,t+k}-1}}} = \frac{K_t^j}{F_t^j}, \tag{3.4.10}$$

say, where

$$K_t^j \equiv \lambda_{j,t} E_t \sum_{k=0}^{\infty} (\theta_j \beta)^k \Lambda_{t,t+k} Y_{j,t+k} P_{j,t+k}^{\frac{\lambda_{j,t+k}}{\lambda_{j,t+k}-1}} MC_{j,t+k}, \tag{3.4.11}$$

$$F_t^j = E_t \sum_{k=0}^{\infty} (\theta_j \beta)^k \Lambda_{t,t+k} Y_{j,t+k} P_{j,t+k}^{\frac{1}{\lambda_{j,t+k}-1}}. \tag{3.4.12}$$

These objects have the following convenient recursive representations

$$K_t^j = \lambda_{j,t} Y_{j,t} \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t} \right) P_{j,t}^{\frac{\lambda_{j,t}}{\lambda_{j,t}-1}} MC_{j,t} + \beta \theta_j K_{t+1}^j, \tag{3.4.13}$$

$$F_t^j = Y_{j,t} \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t} \right) P_{j,t}^{\frac{1}{\lambda_{j,t}-1}} + \beta \theta_j F_{t+1}^j. \tag{3.4.14}$$

To make these equations stationary, we define two new variables in a following way

$$k_t^j = \frac{K_t^j}{P_{j,t}^{\frac{\lambda_{j,t}}{\lambda_{j,t}-1}}} = \lambda_{j,t} Y_{j,t} \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t} \right) MC_{j,t} + \beta \theta_j \Pi_{j,t+1}^{\frac{\lambda_{j,t}}{\lambda_{j,t}-1}} k_{t+1}^j, \tag{3.4.15}$$

$$f_t^j = \frac{F_t^j}{P_{j,t}^{\frac{1}{\lambda_{j,t}-1}}} = Y_{j,t} \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t} \right) + \beta \theta_j \Pi_{j,t+1}^{\frac{1}{\lambda_{j,t}-1}} f_{t+1}^j, \tag{3.4.16}$$

where $\Pi_{H,t}$ is the gross inflation of domestic produced tradable goods and $\Pi_{N,t}$ is the inflation of non-tradable goods.
Turning to the aggregate price index

$$P_{j,t} = \left[\int_0^1 P_{j,t}^{\frac{1}{1-\lambda_{j,t}}}(i) di \right]^{(1-\lambda_{j,t})} = \left[(1-\theta_j)(P^*_{j,t})^{\frac{1}{1-\lambda_{j,t}}} + \theta_j P_{j,t-1}^{\frac{1}{1-\lambda_{j,t}}} \right]^{(1-\lambda_{j,t})}, \tag{3.4.17}$$

dividing both sides by $P_{j,t}$ and rearranging we get

$$p^*_{j,t} = \left[\frac{1 - \theta_j \left(\frac{1}{\Pi_{j,t}} \right)^{\frac{1}{1-\lambda_{j,t}}}}{1-\theta_j} \right]^{1-\lambda_{j,t}}, \tag{3.4.18}$$

where $p^*_{j,t} = \frac{P^*_{j,t}}{P_{j,t}}$.
In sum, the equilibrium conditions associated with price setting are

$$k^j_t = \lambda_{j,t}\left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{j,t}MC_{j,t} + \beta\theta_j \Pi_{j,t+1}^{\frac{\lambda_{j,t}}{\lambda_{j,t-1}}} k^j_{t+1} \quad (3.4.19)$$

$$f^j_t = \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{j,t} + \beta\theta_j \Pi_{j,t+1}^{\frac{1}{\lambda_{j,t-1}}} f^j_{t+1}, \quad (3.4.20)$$

$$\frac{k^j_t}{f^j_t} = \left[\frac{1 - \theta_j\left(\frac{1}{\Pi_{j,t}}\right)^{\frac{1}{1-\lambda_{j,t}}}}{1 - \theta_j}\right]^{1-\lambda_{j,t}}. \quad (3.4.21)$$

$$\hat{p}_{j,t} = \left[(1-\theta_j)\left(\frac{1 - \theta_j(\Pi_{j,t}^{\frac{1}{\lambda_{j,t-1}}})}{1-\theta_j}\right)^{\lambda_{j,t}} + \theta_j\left(\frac{\hat{p}_{j,t-1}}{\Pi_{j,t}}\right)^{\frac{\lambda_{j,t}}{1-\lambda_{j,t}}}\right]^{\frac{1-\lambda_{j,t}}{\lambda_{j,t}}} \quad (3.4.22)$$

where the last equation shows the evolution of price dispersion (see Yun, Tack (1996)).

To get the aggregate output of domestically produced goods, we need to integrate $Y_{j,t}(i)$. For domestic produced tradable goods we get

$$\hat{Y}_{H,t} = \int_0^1 Y_{H,t}(i)di = Y_{H,t}\int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\frac{\lambda_{H,t}}{\lambda_{H,t-1}}} di = Y_{H,t}\hat{p}_{H,t}^{-\frac{\lambda_{H,t}}{\lambda_{H,t-1}}} \quad (3.4.23)$$

On the other side we have

$$\hat{Y}_{H,t} = \int_0^1 Y_{H,t}(i)di = \int_0^1 A_{H,t}N_{H,t}^{(1-\alpha_H)}(i)di = A_{H,t}N_{H,t}^{(1-\alpha_H)} \quad (3.4.24)$$

Combining the last two equations, we get the aggregate production function

$$Y_{H,t} = A_{H,t}N_{H,t}^{(1-\alpha_H)}\hat{p}_{H,t}^{\frac{\lambda_{H,t}}{\lambda_{H,t-1}}} \quad (3.4.25)$$

Taking similar steps, we get the aggregate production function for domestic non-tradable goods

$$Y_{N,t} = A_{N,t}N_{N,t}^{(1-\alpha_N)}\hat{p}_{N,t}^{\frac{\lambda_{N,t}}{\lambda_{N,t-1}}} \quad (3.4.26)$$

3.5 Domestic importers

Importers are also operating in a monopolistic competitive market. They set prices following Calvo (1983). With probability $(1-\theta_F)$ firms set optimal price and with a probability of θ_F they keep prices unchanged. The j-th importer solves the following profit maximization problem

$$\max_{P^*_{F,t}} \sum_{k=0}^{\infty}(\beta\theta_F)^k E_t\left[\Lambda_{t,t+k}\left(\frac{P^*_{F,t}}{P_{F,t+k}} - MC_{F,t+k}\right)Y_{F,t+k}(i)\right], \quad (3.5.1)$$

subject to the demand curve for its good

$$Y_{F,t+k}(i) = \left(\frac{P^*_{F,t}}{P_{F,t+k}}\right)^{-\frac{\lambda_{F,t+k}}{\lambda_{F,t+k}-1}} Y_{F,t+k}, \tag{3.5.2}$$

where

$$\lambda_{F,t} = (1-\rho_{\lambda_F})\lambda_F + \rho_{\lambda_F}\lambda_{F,t-1} + \varepsilon_{\lambda_F,t}$$

Steps of the optimization problem and the derivation of New Keynesian Phillips curve are the same as in the case of home produced goods. The only exception is that the real marginal cost for importers is $MC_{F,t} = \frac{Ex_t P^*_t}{P_{F,t}}$.

The New Keynesian Phillips curve of imported goods is the set of following equations

$$k^F_t = \lambda_{F,t}\left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right) Y_{F,t} MC_{F,t} + \beta\theta_F \Pi_{F,t+1}^{\frac{\lambda_{F,t}}{\lambda_{F,t}-1}} k^F_{t+1} \tag{3.5.3}$$

$$f^F_t = \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right) Y_{F,t} + \beta\theta_F \Pi_{F,t+1}^{\frac{1}{\lambda_{F,t}-1}} f^F_{t+1}, \tag{3.5.4}$$

$$\frac{k^F_t}{f^F_t} = \left[\frac{1 - \theta_F\left(\frac{1}{\Pi_{F,t}}\right)^{\frac{1}{1-\lambda_{F,t}}}}{1-\theta_F}\right]^{1-\lambda_{F,t}}. \tag{3.5.5}$$

$$\hat{p}_{F,t} = \left[(1-\theta_F)\left(\frac{1-\theta_F(\Pi_{F,t}^{\frac{1}{\lambda_{F,t}-1}})}{1-\theta_F}\right)^{\lambda_{F,t}} + \theta_F\left(\frac{\hat{p}_{F,t-1}}{\Pi_{F,t}}\right)^{\frac{\lambda_{F,t}}{1-\lambda_{F,t}}}\right]^{\frac{1-\lambda_{F,t}}{\lambda_{F,t}}} \tag{3.5.6}$$

Because of price dispersion the demand of aggregate import takes the following form

$$Y_{F,t} = \gamma_2\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\eta_2} C_{T,t}\hat{p}_{F,t}^{\frac{\lambda_{F,t}}{\lambda_{F,t}-1}} \tag{3.5.7}$$

3.6 Equilibrium

In equilibrium, all markets must clear. In home economy, the market clearing condition requires that the sum of outputs of traded and non-traded markets equals total output

$$P_{Y,t}Y_t = P_{N,t}Y_{N,t} + P_{T,t}Y_{T,t}. \tag{3.6.1}$$

The whole production on non-tradable sector is consumed at home, and the following identity should hold

$$Y_{N,t} = C_{N,t}. \tag{3.6.2}$$

On the other hand, production of the tradable sector is divided into home and foreign consumption (export)

$$Y_{T,t} = C_{H,t} + Y_{EX,t}. \tag{3.6.3}$$

given the demand function for home produced tradable goods of domestic households as $C_{H,t} = (1-\gamma_2)\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\eta_2} C_{T,t}$ and, following much of the literature, the demand function of foreign households for domestic tradable goods is represented by the following expression

$$Y_{EX,t} = \gamma_2 \left(\frac{P_{H,t}}{Ex_t P_t^*}\right)^{-\eta_2} Y_t^*, \tag{3.6.4}$$

where export is a function of external demand and relative prices. Representing exports in such a functional form is quite common in literature (see Christiano et al. (2011)).

3.7 Relative prices

This section discusses the various stationary relative prices that enter the model. To bring all prices to a stationary form, we divide them by P_t. Dividing (3.1.4) by P_t we get

$$1 = \left[(1-\gamma_1) p_{T,t}^{1-\eta_1} + \gamma_1 (S_{I,t} \cdot p_{H,t})^{1-\eta_1}\right]^{\frac{1}{1-\eta_1}}, \tag{3.7.1}$$

where $p_{H,t} = \frac{P_{H,t}}{P_t}$ is relative domestic produced tradable good price, $p_{T,t} = \frac{P_{T,t}}{P_t}$ is the relative price for tradable goods.

We define the following inflation rates

$$\pi_t = \frac{P_t}{P_{t-1}}, \quad \pi_{F,t} = \frac{P_{F,t}}{P_{F,t-1}}, \quad \pi_t^* = \frac{P_t^*}{P_{t-1}^*}, \quad \pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}}, \quad \pi_{N,t} = \frac{P_{N,t}}{P_{N,t-1}}.$$

For domestic tradable goods inflation we get

$$\pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}} = \frac{p_{H,t} P_t}{p_{H,t-1} P_{t-1}} = \pi_t \frac{p_{H,t}}{p_{H,t-1}} \tag{3.7.2}$$

In the next step we divide (3.1.8) by P_t and get

$$p_{T,t} = \left[(1-\gamma_2) p_{H,t} + \gamma_2 \left(\frac{P_{H,t}}{S_t}\right)^{1-\eta_2}\right]^{\frac{1}{1-\eta_2}} \tag{3.7.3}$$

3.8 Monetary policy

The model is closed by adding Taylor (1993) type monetary policy rule of the form

$$\frac{R_t}{R^{ss}} = \left(\frac{R_{t-1}}{R^{ss}}\right)^{\rho_r} \left\{\left(\frac{\Pi_{t+1}}{\Pi_{ss}}\right)^{\mu_\pi} \left(\frac{Y_{t+1}}{Y_{ss}}\right)^{\mu_y}\right\}^{(1-\rho_r)}. \tag{3.8.1}$$

The Central bank is forward looking with an interest rate persistence component and responds to inflation expectations and the future output gap.

3.9 External world

The home economy is small relative to the rest of the world and cannot impact on it. The external sector is modelled exogenously. Foreign demand, inflation and interest rate follow first order autoregressive processes

$$y_t^* = \rho_y^* y_{t-1} + (1-\rho_y^*) y^{ss} + \sigma_{y,t}^*, \tag{3.9.1}$$

$$\pi_t^* = \rho_\pi^* \pi_{t-1}^* + (1-\rho_\pi^*) \pi^{ss} + \sigma_{\pi,t}^*, \tag{3.9.2}$$

$$r_t^* = \rho_r^* r_{t-1}^* + (1-\rho_r^*) r^{ss} + \sigma_{r,t}^*, \tag{3.9.3}$$

where $\rho_y^*, \rho_\pi^*, \rho_r^* \in (0,1)$ are persistence coefficients, y^{ss}, π^{ss}, r^{ss} are steady state values of foreign demand, inflation and interest rate respectively and $\sigma_{y,t}^*, \sigma_{\pi,t}^*, \sigma_{r,t}^*$ are independent and identically distributed error terms with zero mean.

3.10 Steady state

In Appendix 1, we show how to calculate the steady state of the model. Here, the paper discusses the steady states of some most notable variables from the view of policy analysis.

First, consider the steady state values of employment in two sectors.

$$N_N = \left(\frac{\gamma_1 (1-\alpha_N)(1-\beta h)}{\chi_1 (1-\tau_N)(1-h)\lambda_N} \right)^{\frac{1}{1+\phi_1}} \tag{3.10.1}$$

$$N_H = \left(\frac{\gamma_1 (1-\alpha_H)(1-\beta h) Y_H}{\chi_2 (1-\tau_H)(1-h)\lambda_H C_H} \right)^{\frac{1}{1+\phi_2}} \tag{3.10.2}$$

Equations (3.10.1) and (3.10.2) show that in both sectors the employment rate has positive relation with the rate of subsidy of that sector and with the consumption habit parameter. Conversely, it is negatively correlated with the rate of markup and with the disutility that one gets from additional working hours. While all parameters are structural and, therefore, are determined in an economy, the subsidy is a policy tool that government can use to affect the economy by changing the labor allocation in a steady state. Daveri and Tabellini (2000) also shows that there is a positive correlation between tax rate and unemployment. In appendix 4 we show the empirical evidence for positive link between employment and subsidy for number of developing countries.

Since the model is constructed in a way that increasing the subsidy of one sector has the same effect as decreasing the markup of that sector (both shocks have almost the same impulse response functions) during the estimation of the model we excluded the subsidies to avoid having redundant variables. We define the ratio of tradable employment to non-tradable one as the proxy of the ratio of firms operating in these two sectors

$$RL = \frac{N_H^{(1-\alpha_H)}}{N_N^{(1-\alpha_N)}} \tag{3.10.3}$$

The dynamics of this ratio shows the long run productivity of the economy.

3.11 Model calibration

In this subsection we discuss the calibration of the baseline model. Consistent with the empirical analysis, it is calibrated on a quarterly basis. We set the disutility parameter from working for each sector to be equal $\chi_1 = \chi_2 = 1$, (this parameter is more relevant when the model implies unemployment in a steady state and χ is calibrated in a way to reflect the rate of unemployment in a steady state) the Frisch elasticity of labor supply $\varphi_1 = \varphi_2 = 2$ following Grabek et al. (2013) and following Smets and Wouters (2007) we set the value of habit persistence to be $h = 0.7$.

The elasticity of substitution between tradable and non-tradable goods as well as between home produced and imported tradable goods are set to 1.5, which is standard value used in the macro literature, see, e.g., Chari et al. (2002), Adolfson et al. (2007).

The coefficients of the reaction of interest rate to inflation expectations μ_π and future output gap μ_y are set 1.5 and 0.5 respectively, in line with the values proposed by Taylor (1993). The value of the smoothing parameter in Taylor type rule ρ_r is calibrated to 0.6. These values are commonly used in the literature.

The discount factor β is set at 0.99 to imply a real interest rate of 4%. The share of non-tradable goods in CPI is set to $\gamma_1 = 0.35$ and the share of imported tradable goods is calibrated to $\gamma_2 = 0.5$. The share of capital is assumed to be higher in tradable sector, so we set $\alpha_T = 0.6$ and $\alpha_N = 0.3$.

Following Semko (2013) and the estimates of Kolasa (2008) the price stickiness parameter of imported goods is calibrated to 0.5, i.e. prices stay unchanged for two quarters on average. Since, the vast literature referring to emerging economies shows that the price stickiness of non-tradable goods is higher than that of tradable goods we set $\theta_N = 0.7$ and $\theta_H = 0.4$

Table 1: Estimates of price stickiness for different countries

Paper	Country	θ_N	θ_H
Abrisko (2015)	Czech republic	0.42	Perfect competition ($\theta_H = 0$)
Cristadoro et al. (2006)	EA	0.75	0.52
Kolasa (2008)	Poland	0.79	0.55
Semko, Roman (2013)	Russia	0.73	0.51
Viziniuc (2013)	Romania	0.52	0.34

Table 2: Calibrated parameters

	Description	Value
β	Discount factor	0.99
γ_1	Share of non-tradable goods in CPI	0.35
γ_2	Share of imported tradable goods in traded goods component of CPI	0.5
$1-\alpha_T$	Share of labor in production function of tradable sector	0.4
$1-\alpha_N$	Share of labor in production function of non-tradable sector	0.7
χ_1	Disutility parameter of non-tradable sector worker	1.0
χ_2	Disutility parameter of tradable sector worker	1.0
h	Habit parameter	0.7
θ_H	Price stickiness coefficient of home-produced tradable goods	0.4
θ_N	Price stickiness coefficient of non-tradable goods	0.7
θ_F	Price stickiness coefficient of imported goods	0.5
η_1	Elasticity of substitution between tradable and non-tradable goods	1.5
η_2	Elasticity of substitution between home-produced and imported goods	1.5
φ_1	Inverse of the elasticity of labor supply for non-tradable sector	2.0
φ_2	Inverse of the elasticity of labor supply for tradable sector	2.0
ρ_r	Persistence coefficient of interest rate	0.6
μ_π	Reaction of interest rate to inflation expectations in Taylor rule	1.5
μ_y	Reaction of interest rate to future output gap in Taylor rule	0.5

4 Impulse response functions

This section discusses behaviors of the model variables to structural shocks. Appendix 3 provides with the figures of impulse responses. The vertical axis represents percentage deviations of variables from steady state and the horizontal axis shows periods following the shock.

A positive monetary policy shock (figure 4) cuts consumption through Euler equation and appreciates nominal exchange rate through the uncovered interest rate parity condition. Firms from both tradable and non-tradable sectors, in a response to low demand, reduce their hires of labor. The decreased labor puts pressures on marginal costs to go down. As a result, deflation hits the economy. The rise of interest rate appreciates the nominal exchange rate and imported goods become cheaper. However, since the price of imported goods is stickier than the price of home produced tradable goods, terms of trade decreases. Appreciated real exchange rate decreases foreign demand of home-produced tradable goods.

The risk premium shock (figure 5) initially depreciates both nominal and real exchange rates and brings to the rise of exporting goods. Higher exports force tradable firms to increase the demand for labor which triggers the real wage of that sector to rise and hence, the price for home produced tradable goods increases. On the other side, since the depreciation of nominal exchange rate rises the marginal cost of importers, the price of imported goods also goes up. However, because the price of imported goods is stickier than the price of home-produced tradable goods, the terms of trade increases. Due to this, households switch from home-produced tradable goods towards imported and non-tradable goods. Monetary authorities response to high inflation rate by increasing interest rate.

A productivity shock in tradable sector (figure 6) initially forces a decline in marginal cost and tradable sector's employment. Deflation of home produced tradable goods results to the worsened terms of trade. In a period of bad terms of trade, foreign and domestic households increase their demand for domestic tradable goods. The low price of tradable goods appreciates internal terms of trade, which forces households to decline their demand for non-tradable goods. The marginal costs for both tradable and non-tradable sectors decrease the first one because of higher productivity and the second one due to lower demand. As a result we get deflation. The monetary policy rule reacts to deflation by decreasing nominal interest rate.

A productivity shock (figure 7) in non-tradable sector decreases marginal cost of that sector's producers and leads them to decline prices of their goods. Deflation in non-tradable sector worsens internal terms of trade thus households substitute tradable goods with non-tradable ones. As a result prices for all types of goods decreases and Central bank increases the interest rate.

5 Evaluating the long-run effects of structural reforms

To assess the macroeconomic impact of reforms aimed at reallocating labor resources between tradable and non-tradable sectors as well as the impact of nominal exchange rate depreciation, we use the calibrated version of the model. Initially the economy starts from some level of subsidies, which are modelled as AR(1) processes and the persistence parameter determines the time it takes for subsidies to converge the new equilibrium level. The simulations are deterministic, which means that households and firms have perfect foresight, thereby eliminating any uncertainty concerning the credibility of the reforms.

For each simulation, we report the long-run values of the main macroeconomic variables and the transition dynamics from the initial steady state to the new one, following a 20 percentage point reduction in subsidies. For exchange rate policy analysis we also do sensitivity analysis by changing the values of some key parameters. Finally, we transform the generated variables from the simulations in a way that they start from zero and go to their new steady state, this is done to better illustrate the difference between old and new equilibrium points.

5.1 Decreasing non-tradable sector subsidy

Figure 1 shows the transition dynamics from the initial to the new steady state, reducing the non-tradable subsidy. As mentioned in model block, we represent subsidies as AR(1) processes and first, we set the persistence coefficient 0.9, meaning that the level of subsidy reaches to its new equilibrium level in 32 periods. The reduction of non-tradable subsidies reduces the number of non-tradable firms (here we use the employment rate of each sector as a proxy for the number of firms operating in that sector) because in a steady state the number of firms is a function of the level of subsidy. Decreasing the number of non-tradable firms puts a downward pressure on the real wages of that sector, which leads to a negative gap in the marginal costs to that sector. As a result, we get short-term deflation of non-tradable goods and services. On the other side, as the real exchange rate depreciates, the foreign demand for domestic produced goods increases, which triggers the tradable firms to increase their output, hiring more labor. The consumption decreases, which has a negative impact on inflation and hence, as in the case of non-tradable goods inflation, we get negative headline inflation. To conclude, cutting the subsidies of non-tradable sector brings the economy in a state, where the number of tradable firms is bigger than the number of non-tradable ones, the net export is higher, meaning that the economy becomes more export oriented. The main cost of implementing such policy are negative inflation rate (deflation), which is prolonged.

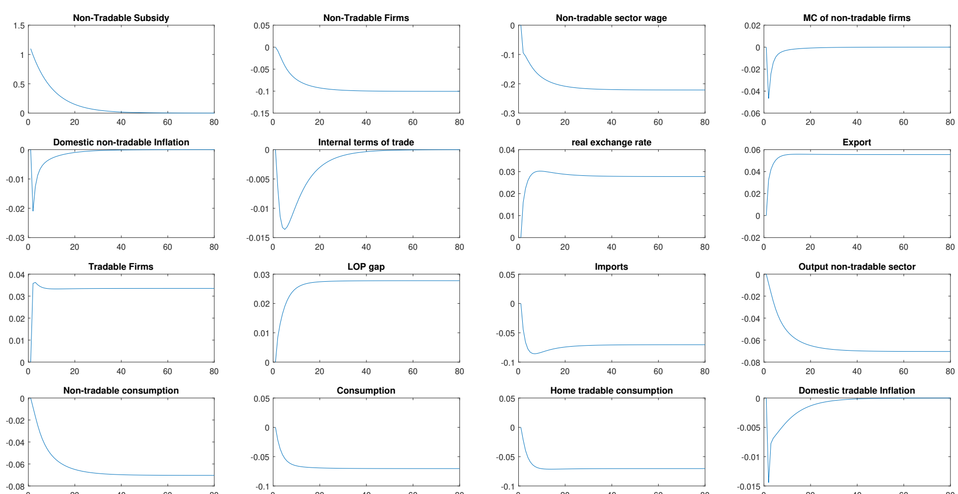


Figure 8 (Appendix 4) shows the results of implementing the same policy as in the first case, except the fact that the persistence coefficient is 0.6, which means that the subsidy converges to its new steady state more rapidly (16 peri-

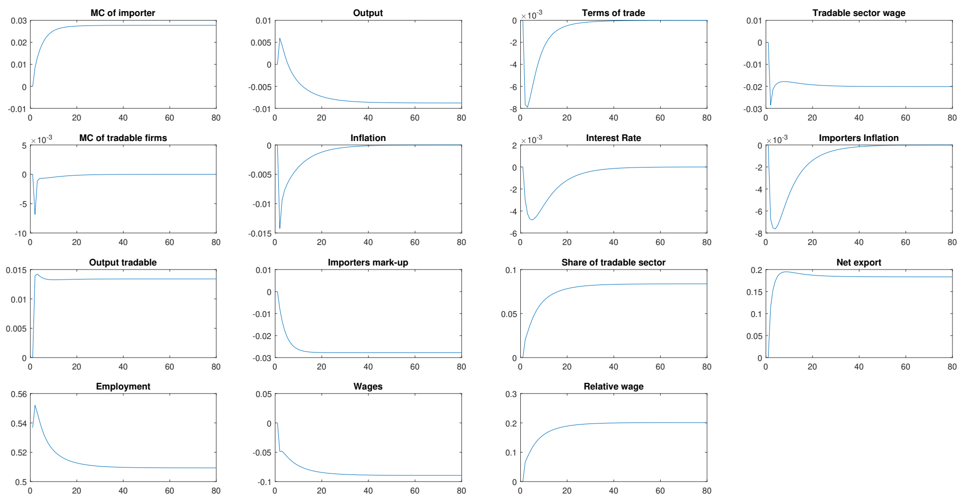


Figure 1: Structural reforms in non-tradable sector

ods). Since the steady state values does not change we get the same equilibrium points for all variables, the main difference is that the inflation becomes more volatile jumping above its steady state at the first period and then falling down.

5.2 Increasing tradable sector subsidy

Figure 2 illustrates the effects of gradually increasing the subsidy given to tradable sector along with the transition path to the new steady state (we set persistence coefficient 0.9). By giving more subsidy to the tradable sector we increase the demand for labor for that sector, which leads to higher real wage of that sector and we get inflationary pressures from tradable sector. Since consumption does not change its steady state, (this comes from model specification) the extra output produced in tradable sector is being exported. As for non-tradable sector, initially, the consumption of non-tradable goods increases because of worsened internal terms of trade. Higher consumption of non-tradable goods increases the demand of labor. As a result, the price of non-tradable goods increases. However, changes related to non-tradable sector are temporarily and as a result they do not change their steady states. Overall, giving direct subsidies to tradable firms leads the economy to a new state where the level of net export and the ratio of tradable to non-tradable firms are higher.

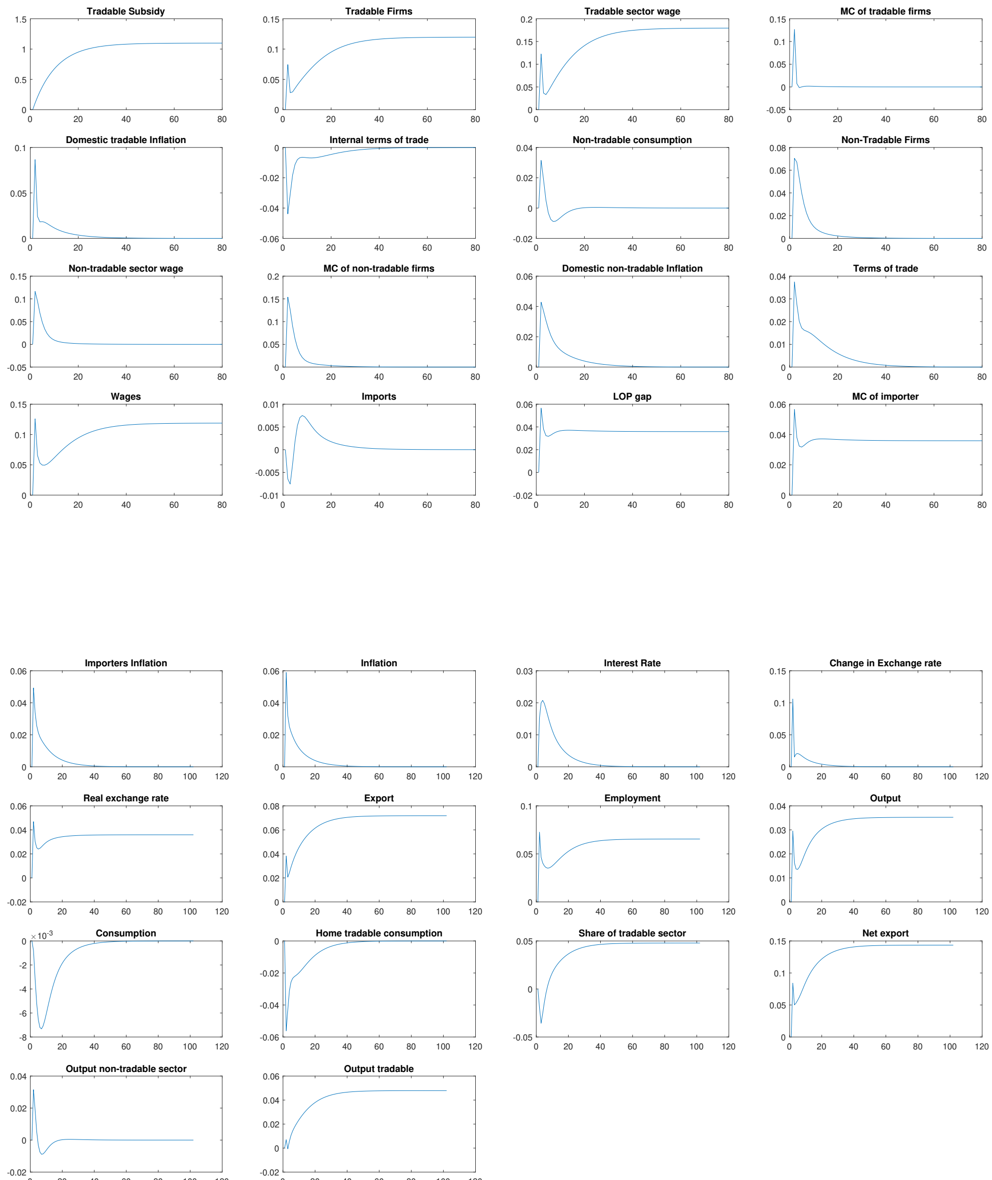
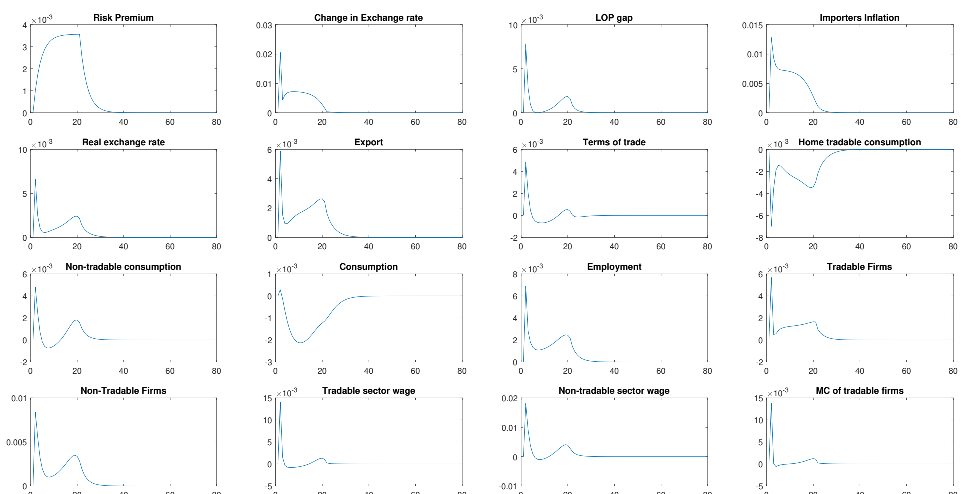


Figure 2: Structural reforms in tradable sector

6 Exchange rate policy

To simulate the nominal exchange rate depreciation, we give a positive deterministic shock to the risk premium for 20 periods. Figure 3 shows that a positive risk premium shock depreciates the nominal exchange rate through the UIP condition. This increases the marginal cost of importers, therefore, the price of imported goods. The depreciation of nominal exchange rate also depreciates the real exchange rate, which leads to higher exports. Firms operating in tradable sector hire more labor increasing the real wage of that sector, which triggers the marginal cost to go up. As a result, the price of tradable goods increases. Higher price of tradable goods worsens the internal terms of trade and consumers substitute home-produced tradable goods with non-tradable goods. The increased demand of non-tradable goods increases the price of that goods. Overall, the economy appears in a state with high inflation and the Central bank responds to this by increasing the interest rate. However, since the price of domestic tradable goods is much stickier than the price of non-tradable goods the number of firms operating in non-tradable sector increases and remains above its steady state value much longer than the number of firms operating in tradable sector. As a result, the ratio of tradable to non-tradable firms is negative, which indicates that the long run effect of such a policy could be the adverse what we expect.



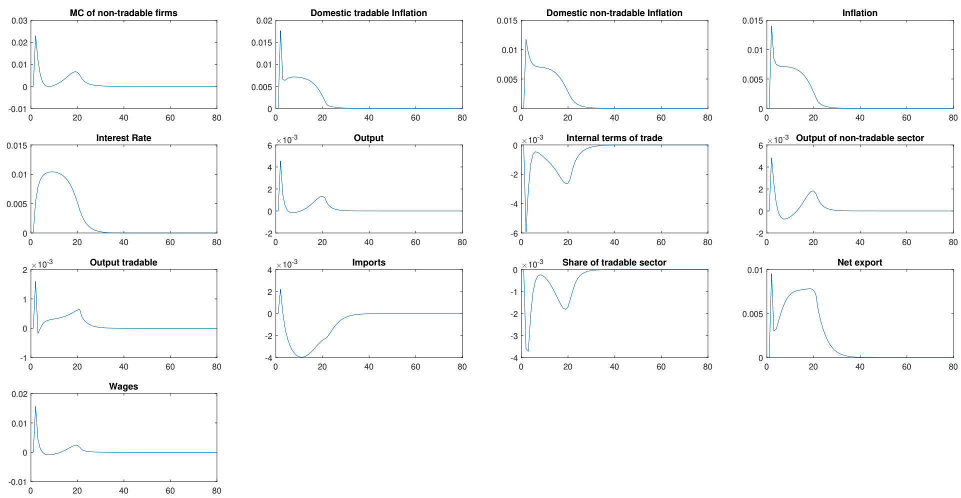


Figure 3: Exchange rate policy (baseline)

6.1 Sensitivity analysis

In this subsection we provide a sensitivity analysis to assess the results of exchange rate policy by changing the values of some structural parameters of the model. First, figure 9 in Appendix 4 illustrates the impulse response functions of an exchange rate shock for 2 alternative calibrations of price stickiness together with baseline calibration. First, we set the $\theta_N = 0.43$ and $\theta_H = 0.7$ making the non-tradable goods price more flexible than the price of tradable goods (as one can see from Table 2 we simply assign the value of non-tradable price stickiness to tradable goods price stickiness and vice versa). As for the second case, we make all sectors equally sticky by setting $\theta_N = \theta_H = \theta_F = 0.5$. The graphs show that for the first alternative scenario the economy appears in a state, where the number of tradable firms is higher than the number of non-tradables. In the second case although the deviations of their steady states for the most variables are relatively bigger the persistence of these shocks are lower. As a result, the economy returns to its initial state very fast. The last case can also be considered as the starting point for drawing some conclusion, namely, if the price stickiness parameters of different sectors are close to each other then the results of such a policy will be similar to the third scenario, otherwise depending on which sector goods' price is more sticky the effects will be closer to one of the first two cases.

Lastly, we provide the results of IRFs for other cases, particularly, in figure 10, in line with baseline calibration, we introduce other calibrations by changing the elasticity of substitution between tradable and non-tradable goods making them less or more complement goods by setting $\eta_1 = 0.5$ and $\eta_1 = 8$ respectively.

The graphs show that although the size of responses of the variables (we show the responses only for most relevant variables) has been changed, the directions have remained the same. Figures 11-12 show the same exercise for η_2 (elasticity of substitution between home-produced and foreign tradable goods) and for habit persistence. The conclusions are the same as in the case of η_1.

7 Conclusion

We construct a dynamic general equilibrium model, dividing the economy into two main sectors and try to estimate the long-run effects of both structural reforms and the exchange rate depreciation as a policy tool for boosting the economy. For not losing the generality, we first calibrate the model by setting the most common values given in literature for each structural parameter and then evaluate the effects of the shocks by changing them. Model dynamics reveal that the results of exchange rate policy are sensitive to price rigidity across sectors. In order to analyse the effects of structural reforms, we change the steady state values of the subsidies that the government gives to the sectors. The model is constructed in such a way, that the steady state value of each sector employment is a function of its subsidy level, therefore by changing the steady state level of the subsidy we can change the number of firms operating in that sector.

To conclude, our paper shows that the effects of exchange rate policy can be ambiguous, depending on the structure of the economy. On the other hand, giving a direct subsidy to tradable sector (or cutting the subsidy of non-tradable sector) can be more beneficial in the long run irrelevant from the current state of the economy. The most relevant parameter, which determines the effect of exchange rate policy on market structure, is price stickiness. For making our inference stronger, we have done sensitivity analysis by changing some structural parameters.

For further research we suggest following: extend the model by adding more realistic labor market (sticky wages, labor adjustment, searching matching frictions), include the government as an utility maximizing agent and investigate an optimal fiscal policy, define an endogenous foreign exchange rate policy and estimate possible implications. Finally, a proper welfare analysis is beyond the current scope of the paper and is something we leave for future work.

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8 Appendix

8.1 Appendix 1. Steady state

In this subsection, we will compute the steady state in the model. First, we assume that in steady state all prices are equal, hence we get

$$p_H = \frac{P_H}{P} = 1 \tag{8.1.1}$$

$$p_T = \frac{P_T}{P} = 1 \tag{8.1.2}$$

$$\hat{p}_N = \hat{p}_H = \hat{p}_F = 1 \tag{8.1.3}$$

$$S = \frac{P_H}{P_F} = 1, \tag{8.1.4}$$

$$S_I = \frac{P_N}{P_H} = 1, \tag{8.1.5}$$

also,

$$\pi_H = \pi_N = \pi_F = \pi = 1 \tag{8.1.6}$$

Next, we assume that in a steady state the risk premium of the country is one and that both domestic and foreign gross interest rates are $\frac{1}{\beta}$.

Solving the equations (2.4.21)-(2.4.24) and (2.5.3)-(2.5.6) (same computations are done for importing goods prices) in a steady state, we get the following results

$$\frac{k^j}{f^j} = \left[\frac{1-\theta_j}{1-\theta_j}\right]^{1-\lambda_j} = 1 \tag{8.1.7}$$

$$k^j = \lambda_j \frac{1-\beta h}{C-hC} Y_j MC_j + \beta\theta_j k^J \tag{8.1.8}$$

$$f^J = k^J \tag{8.1.9}$$

$$\lambda_j \frac{1-\beta h}{C-hC} Y_j MC_j + \beta\theta_j k^j = \frac{1-\beta h}{C-hC} Y_j + \beta\theta_j f^j \tag{8.1.10}$$

As a result, we get the following steady state values for sectoral real marginal costs and auxiliary variables

$$MC_H = \frac{1}{\lambda_H} \tag{8.1.11}$$

$$MC_N = \frac{1}{\lambda_N} \tag{8.1.12}$$

$$MC_F = \frac{1}{\lambda_F} \tag{8.1.13}$$

$$k^H = f^H = \frac{Y_H}{1-\beta\theta_H} \frac{1-\beta h}{C-hC} \tag{8.1.14}$$

$$k^F = f^F = \frac{Y_F}{1-\beta\theta_F} \frac{1-\beta h}{C-hC} \tag{8.1.15}$$

$$k^N = f^N = \frac{Y_N}{1-\beta\theta_N}\frac{1-\beta h}{C-hC} \tag{8.1.16}$$

where $\lambda_H \quad \lambda_N \quad \lambda_F$ are steady state values of tradable, non-tradable and importing sectors' mark-up. The steady state mark-ups of tradable and non-tradable sectors are defined exogenously.

Combining the equations (2.4.9) (2.1.16) (2.1.5) and the aggregate production function of non-tradable firms $Y_N = A_N N_N^{(1-\alpha_N)}$, we get the following steady states

$$N_N = \left(\frac{\gamma_1(1-\alpha_N)(1-\beta h)}{\chi_1(1-\tau_N)(1-h)\lambda_N}\right)^{\frac{1}{1+\phi_1}} \tag{8.1.17}$$

$$Y_N = A_N N_N^{(1-\alpha_N)} \tag{8.1.18}$$

$$C_N = Y_N \tag{8.1.19}$$

$$C = \frac{C_N}{\gamma_1} \tag{8.1.20}$$

$$W_N^* = \chi_1 N_N^{\varphi_1} C \tag{8.1.21}$$

where $N_N \quad Y_N \quad C_N \quad W_N^*$ are employment rate, total output, total consumption and real wage for non-tradable sector respectively and C is the consumption basket. From this point the derivation of steady states for the rest of variables is relatively easy.

Combining (2.1.17) and (2.4.8) we derive the steady states for the employment rate and for the real wage in tradable sector

$$N_H = \left(\frac{\gamma_1(1-\alpha_H)(1-\beta h)Y_H}{\chi_2(1-\tau_H)(1-h)\lambda_H C_H}\right)^{\frac{1}{1+\phi_2}} \tag{8.1.22}$$

$$W_H^* = \chi_2 N_H^{\varphi_2} C \tag{8.1.23}$$

We assume that productivity for each sector is given and that the productivity of tradable sector is higher than that of non-tradable sector. The real exchange rate is one and the change in nominal exchange rate $\Delta e_t = \frac{e_t}{e_{t-1}}$ is equal to one in steady state.

The steady state values for the rest of variables can be written as follows:

$$Y_H = A_H N_H^{1-\alpha_H} \tag{8.1.24}$$

$$C_H = (1-\gamma_1)(1-\gamma_2)C \tag{8.1.25}$$

$$Y_{EX} = Y_H - C_H \tag{8.1.26}$$

$$\Phi = \left(\frac{Y_{EX}}{\gamma_2 Y^*}\right)^{\frac{1}{\eta_2}} \tag{8.1.27}$$

$$Q = \Phi \tag{8.1.28}$$

$$Y = Y_H + Y_N \tag{8.1.29}$$

$$Y_F = \gamma_2 C \tag{8.1.30}$$

$$RL = \frac{N_H^{1-\alpha_H}}{N_N^{1-\alpha_N}} \tag{8.1.31}$$

8.2 Appendix 2. Model equations

1.Labor supply in non-tradable sector

$$W^*_{N,t} = \frac{W_{N,t}}{P_t} = \chi_1 N^{\varphi_1}_{N,t} \frac{(C_t - hC_{t-1})(C_{t+1} - hC_t)}{C_{t+1} - hC_t - \beta h(C_t - hC_{t-1})}, \tag{8.2.1}$$

2. Labor supply in tradable sector

$$W^*_{H,t} = \frac{W_{H,t}}{P_t} = \chi_2 N^{\varphi_2}_{H,t} \frac{(C_t - hC_{t-1})(C_{t+1} - hC_t)}{C_{t+1} - hC_t - \beta h(C_t - hC_{t-1})}. \tag{8.2.2}$$

3. Euler Equation

$$\beta R_t E_t \left\{ \frac{(C_{t+2} - hC_{t+1} - \beta h(C_{t+1} - hC_t))(C_t - hC_{t-1})}{(C_{t+1} - hC_t - \beta h(C_t - hC_{t-1}))(C_{t+2} - hC_{t+1})} \frac{P_t}{P_{t+1}} \right\} = 1, \tag{8.2.3}$$

4. UIP condition

$$R_t = R^*_t \frac{Ex_{t+1}}{Ex_t} \varepsilon_{premium,t} \tag{8.2.4}$$

5. Terms of trade

$$\frac{S_t}{S_{t-1}} = \frac{\pi_{H,t}}{\pi_{F,t}} \tag{8.2.5}$$

6.Internal terms of trade

$$\frac{S_{I,t}}{S_{I,t-1}} = \frac{\pi_{N,t}}{\pi_{H,t}} \tag{8.2.6}$$

7. Real effective exchange rate

$$Q_t = \Phi_t \frac{p_{H,t}}{S_t} \tag{8.2.7}$$

8. LOP gap

$$\frac{\Phi_t}{\Phi_{t-1}} = \frac{Ex_t}{Ex_{t-1}} \frac{\pi^*_t}{\pi_{F,t}} \tag{8.2.8}$$

9. Non-tradable firms' production function

$$Y_{N,t} = A_{N,t} N^{1-\alpha_N}_{N,t} \hat{p}^{\frac{\lambda_{N,t}}{\lambda_{N,t}-1}}_{N,t} \tag{8.2.9}$$

10. Domestic tradable firms' production function

$$Y_{H,t} = A_{H,t} N^{1-\alpha_H}_{H,t} \hat{p}^{\frac{\lambda_{H,t}}{\lambda_{H,t}-1}}_{H,t} \tag{8.2.10}$$

11. Marginal cost of domestic tradable firms

$$MC_{H,t} = \frac{W^*_{H,t}(1 - \tau_{H,t}) N^{\alpha_H}_{H,t}}{(1 - \alpha_H) p_{H,t} A_{H,t}} \tag{8.2.11}$$

12. Marginal cost of non-tradable firms

$$MC_{N,t} = \frac{W^*_{N,t}(1-\tau_{N,t})N^{\alpha_N}_{N,t}}{(1-\alpha_N)S_{I,t}p_{H,t}A_{N,t}} \tag{8.2.12}$$

13. Market clearing condition for non-tradable firms

$$Y_{N,t} = C_{N,t} \tag{8.2.13}$$

14. Exports

$$Y_{EX,t} = \gamma_2\left(\frac{S_t}{\Phi_t}\right)^{-\eta_2} Y^*_t \tag{8.2.14}$$

15. Overall output

$$Y_t = p_{H,t}Y_{H,t} + S_{I,t}p_{H,t}Y_{N,t} \tag{8.2.15}$$

16. Market clearing condition for domestic produced tradable firms

$$Y_{H,t} = C_{H,t} + Y_{EX,t} \tag{8.2.16}$$

17. Consumption of non-tradable goods

$$C_{N,t} = \gamma_1(S_{I,t}p_{H,t})^{-\eta_1}C_t \tag{8.2.17}$$

18.Imports

$$Y_{F,t} = \gamma_2\left(\frac{p_{H,t}}{S_t}\right)^{-\eta_2}(1-\gamma_1)(p_{T,t})^{-\eta_1}C_t\hat{p}_{F,t}^{\frac{\lambda_{F,t}}{\lambda_{F,t}-1}} \tag{8.2.18}$$

19. Marginal cost of importing imports

$$MC_{F,t} = \Phi_t(1-\tau_{F,t}) \tag{8.2.19}$$

20. First auxiliary variable of imported goods Phillips curve

$$k^F_t = \lambda_{F,t}\left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{F,t}MC_{F,t} + \beta\theta_F\pi_{F,t+1}^{\frac{\lambda_{F,t}}{\lambda_{F,t}-1}}k^F_{t+1} \tag{8.2.20}$$

21. Second auxiliary variable of imported goods Phillips curve

$$f^F_t = \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{F,t} + \beta\theta_F\pi_{F,t+1}^{\frac{1}{\lambda_{F,t}-1}}f^F_{t+1}, \tag{8.2.21}$$

22. Optimal ratio in imported goods

$$\frac{k^F_t}{f^F_t} = \left[\frac{1-\theta_F\left(\frac{1}{\pi_{F,t}}\right)^{\frac{1}{1-\lambda_{F,t}}}}{1-\theta_F}\right]^{1-\lambda_{F,t}}. \tag{8.2.22}$$

23. Price distortion of imported goods

$$\hat{p}_{F,t} = \left[(1-\theta_F)\left(\frac{1-\theta_F(\pi_{F,t}^{\frac{1}{\lambda_{F,t}-1}})}{1-\theta_F}\right)^{\lambda_{F,t}} + \theta_F\left(\frac{\hat{p}_{F,t-1}}{\pi_{F,t}}\right)^{\frac{\lambda_{F,t}}{1-\lambda_{F,t}}}\right]^{\frac{1-\lambda_{F,t}}{\lambda_{F,t}}} \tag{8.2.23}$$

24. First auxiliary variable of domestic tradable goods Phillips curve

$$k_t^H = \lambda_{H,t}\left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{H,t}MC_{H,t} + \beta\theta_H \pi_{H,t+1}^{\frac{\lambda_{H,t}}{\lambda_{H,t}-1}} k_{t+1}^H \tag{8.2.24}$$

25. Second auxiliary variable of domestic tradable goods Phillips curve

$$f_t^H = \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{H,t} + \beta\theta_H \pi_{H,t+1}^{\frac{1}{\lambda_{H,t}-1}} f_{t+1}^H, \tag{8.2.25}$$

26. Optimal ratio in domestic tradable goods

$$\frac{k_t^H}{f_t^H} = \left[\frac{1 - \theta_H\left(\frac{1}{\pi_{H,t}}\right)^{\frac{1}{1-\lambda_{H,t}}}}{1 - \theta_H}\right]^{1-\lambda_{H,t}}. \tag{8.2.26}$$

27. Price distortion of domestic tradable goods

$$\hat{p}_{H,t} = \left[(1-\theta_H)\left(\frac{1 - \theta_H(\pi_{H,t}^{\frac{1}{\lambda_{H,t}-1}})}{1 - \theta_H}\right)^{\lambda_{j,t}} + \theta_H\left(\frac{\hat{p}_{H,t-1}}{\pi_{H,t}}\right)^{\frac{\lambda_{H,t}}{1-\lambda_{H,t}}}\right]^{\frac{1-\lambda_{H,t}}{\lambda_{H,t}}} \tag{8.2.27}$$

28. First auxiliary variable of domestic tradable goods Phillips curve

$$k_t^N = \lambda_{N,t}\left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{N,t}MC_{N,t} + \beta\theta_N \pi_{N,t+1}^{\frac{\lambda_{N,t}}{\lambda_{N,t}-1}} k_{t+1}^N \tag{8.2.28}$$

29. Second auxiliary variable of domestic tradable goods Phillips curve

$$f_t^N = \left(\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right)Y_{N,t} + \beta\theta_N \pi_{N,t+1}^{\frac{1}{\lambda_{N,t}-1}} f_{t+1}^N, \tag{8.2.29}$$

30. Optimal ratio in domestic tradable goods

$$\frac{k_t^N}{f_t^N} = \left[\frac{1 - \theta_N\left(\frac{1}{\pi_{N,t}}\right)^{\frac{1}{1-\lambda_{N,t}}}}{1 - \theta_N}\right]^{1-\lambda_{N,t}}. \tag{8.2.30}$$

31. Price distortion of domestic tradable goods

$$\hat{p}_{N,t} = \left[(1-\theta_N)\left(\frac{1 - \theta_N(\pi_{N,t}^{\frac{1}{\lambda_{N,t}-1}})}{1 - \theta_N}\right)^{\lambda_{N,t}} + \theta_N\left(\frac{\hat{p}_{N,t-1}}{\pi_{N,t}}\right)^{\frac{\lambda_{N,t}}{1-\lambda_{N,t}}}\right]^{\frac{1-\lambda_{N,t}}{\lambda_{N,t}}} \tag{8.2.31}$$

32. Relative price of home-produced tradable goods

$$1 = \left[(1-\gamma_1)p_{T,t}^{(1-\eta_1)} + \gamma_1(S_{I,t}p_{H,t})^{(1-\eta_1)}\right]^{\frac{1}{1-\eta_1}} \tag{8.2.32}$$

33 . Home-produced tradable goods inflation

$$\pi_{H,t} = \pi_t \frac{p_{H,t}}{p_{H,t-1}} \tag{8.2.33}$$

34. Relative price of tradable goods

$$p_{T,t} = \left[(1-\gamma_2) p_{H,t}^{(1-\eta_2)} + \gamma_2 \left[\frac{p_{H,t}}{S_t} \right]^{(1-\eta_2)} \right]^{\frac{1}{1-\eta_2}} \tag{8.2.34}$$

35. Consumption of home-produced tradable goods

$$C_{H,t} = (1-\gamma_2) \left(\frac{p_{H,t}}{p_{T,t}} \right)^{-\eta_2} (1-\gamma_1)(p_{T,t})^{-\eta_1} C_t \tag{8.2.35}$$

36. Equilibrium in foreign market

$$Y_t^* = C_t^* \tag{8.2.36}$$

37. Taylor rule

$$\frac{R_t}{R^{ss}} = \left(\frac{R_{t-1}}{R^{ss}} \right)^{\rho_r} \left[\left(\frac{\Pi_{t+1}}{\Pi_{ss}} \right)^{\mu_\pi} \left(\frac{Y_{t+1}}{Y_{ss}} \right)^{\mu_y} \right]^{(1-\rho_r)} + \sigma_{r,t}. \tag{8.2.37}$$

38. Foreign output

$$Y_t^* = \rho_y^* Y_{t-1}^* + (1-\rho_y^*) Y^{ss} + \sigma_{y,t}^* \tag{8.2.38}$$

39. Foreign inflation

$$\pi_t^* = \rho_\pi^* \pi_{t-1}^* + (1-\rho_\pi^*) \pi^{ss} + \sigma_{\pi,t}^* \tag{8.2.39}$$

40. Foreign interest rate

$$R_t^* = \rho_r^* R_{t-1}^* + (1-\rho_r^*) R^{ss} + \sigma_{r,t}^* \tag{8.2.40}$$

41. Productivity of non-tradable firms

$$A_{N,t} = \rho_{a_N} A_{N,t-1} + (1-\rho_{a_N}) A_N^{ss} + \sigma_{a_N,t} \tag{8.2.41}$$

42. Productivity of domestic tradable firms

$$A_{H,t} = \rho_{a_H} A_{H,t-1} + (1-\rho_{a_H}) A_H^{ss} + \sigma_{a_H,t} \tag{8.2.42}$$

43. Markup of domestic tradable firms

$$\lambda_{H,t} = \rho_{\lambda_H} \lambda_{H,t-1} + (1-\rho_{\lambda_H}) \lambda_H^{ss} + \sigma_{\lambda_H,t} \tag{8.2.43}$$

44. Markup of non-tradable firms

$$\lambda_{N,t} = \rho_{\lambda_N} \lambda_{N,t-1} + (1-\rho_{\lambda_N}) \lambda_N^{ss} + \sigma_{\lambda_N,t} \tag{8.2.44}$$

45. Importers' markup

$$\lambda_{F,t} = \rho_{\lambda_F}\lambda_{F,t-1} + (1-\rho_{\lambda_F})\lambda_F^{ss} + \sigma_{\lambda_F,t} \tag{8.2.45}$$

46. Subsidy to domestic tradable firms

$$\tau_{H,t} = \rho_{\tau_H}\tau_{H,t-1} + (1-\rho_{\tau_H})\tau^{ss} + \sigma_{\tau_H,t} \tag{8.2.46}$$

47. Subsidy to non-tradable firms

$$\tau_{N,t} = \rho_{\tau_N}\tau_{N,t-1} + (1-\rho_{\tau_N})\tau^{ss} + \sigma_{\tau_N,t} \tag{8.2.47}$$

48. Subsidy to importing firms

$$\tau_{F,t} = \rho_{\tau_F}\tau_{F,t-1} + (1-\rho_{\tau_F})\tau^{ss} + \sigma_{\tau_F,t} \tag{8.2.48}$$

49. Risk premium

$$\varepsilon_{prem,t} = \rho_{prem}\varepsilon_{prem,t-1} + (1-\rho_{prem})\varepsilon_{prem}^{ss} + \sigma_{prem,t} \tag{8.2.49}$$

50. Ratio of tradable and non-tradable labors

$$RL_t = \frac{N_{H,t}^{(1-\alpha_T)}}{N_{N,t}^{(1-\alpha_N)}} \tag{8.2.50}$$

51. Preference shock

$$\xi_t^d = \rho_{\xi^d}\xi_{t-1}^d + (1-\rho_{\xi^d})\xi^{ss} + \sigma_{\xi^d,t} \tag{8.2.51}$$

54. Nominal exchange rate

$$EX_t = EX_{t-1}\Delta e_t \tag{8.2.52}$$

55. Employment

$$N_t = N_{N,t} + N_{H,t} \tag{8.2.53}$$

56. Average real wage

$$W_t = \frac{N_N^{ss}}{N^{ss}}W_{N,t}^* + \frac{N_H^{ss}}{N^{ss}}W_{H,t}^* \tag{8.2.54}$$

8.3 Appendix 3. Impulse response functions

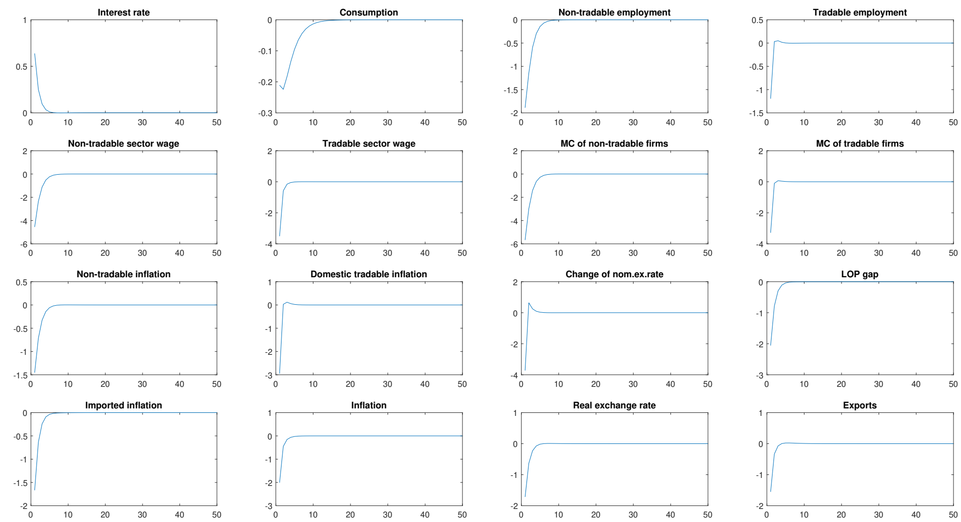


Figure 4: Impulse response to monetary policy shock

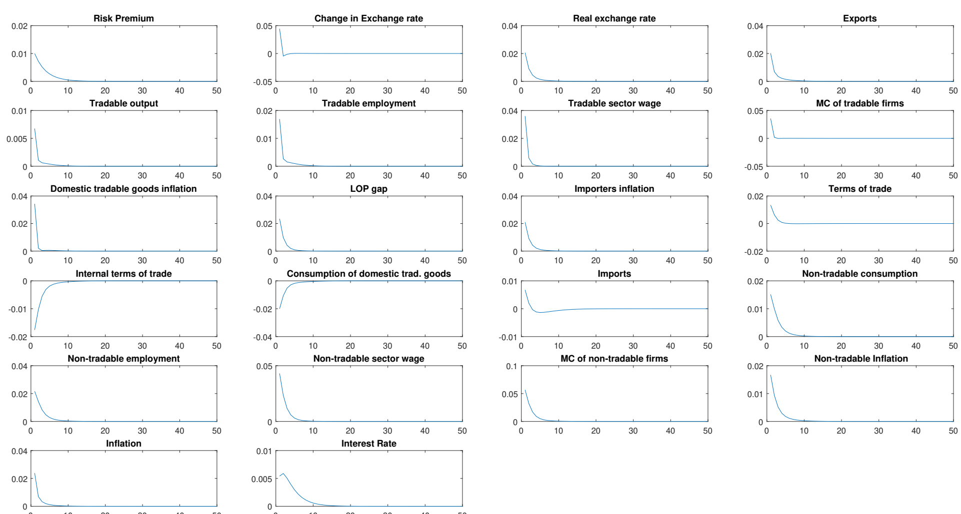


Figure 5: Impulse response to risk premium shock

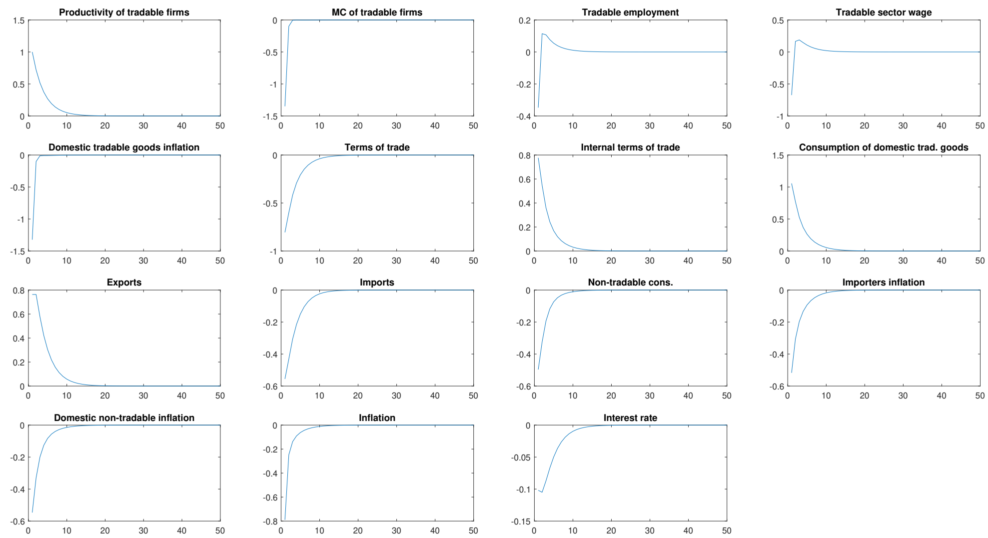


Figure 6: Impulse response to tradable productivity shock

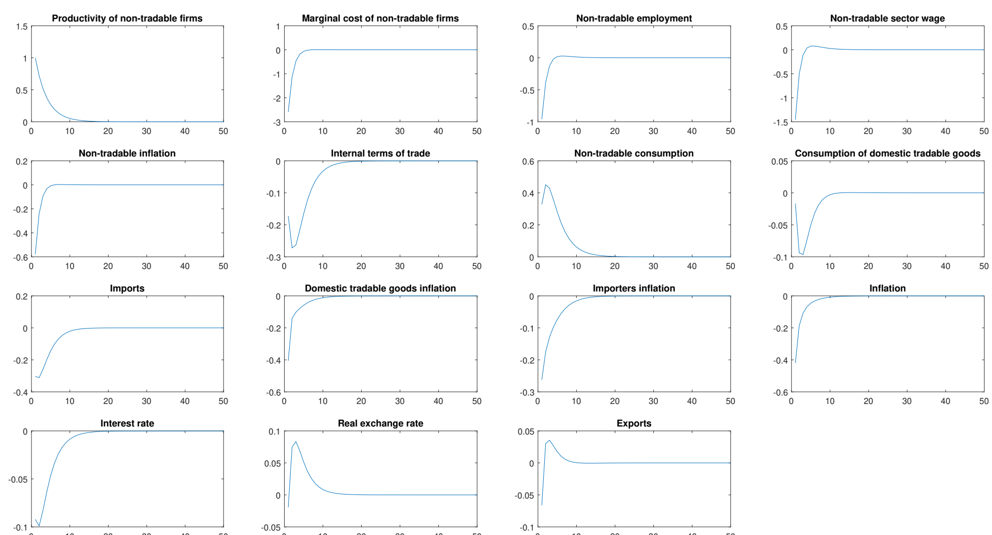


Figure 7: Impulse response to non-tradable productivity shock

8.4 Appendix 4. Transition dynamics of structural reforms and policy analysis

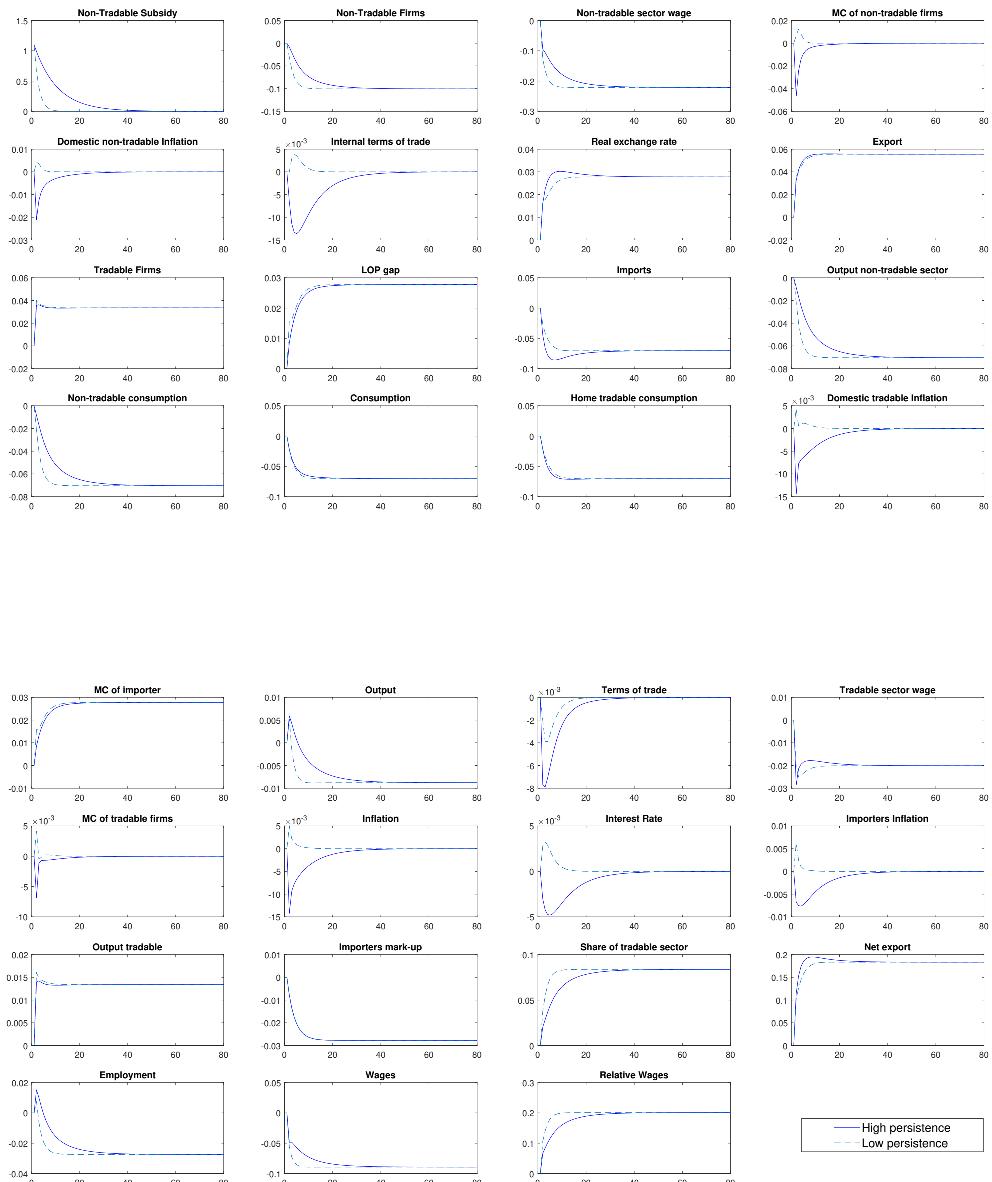


Figure 8: Structural reforms in non-tradable sector

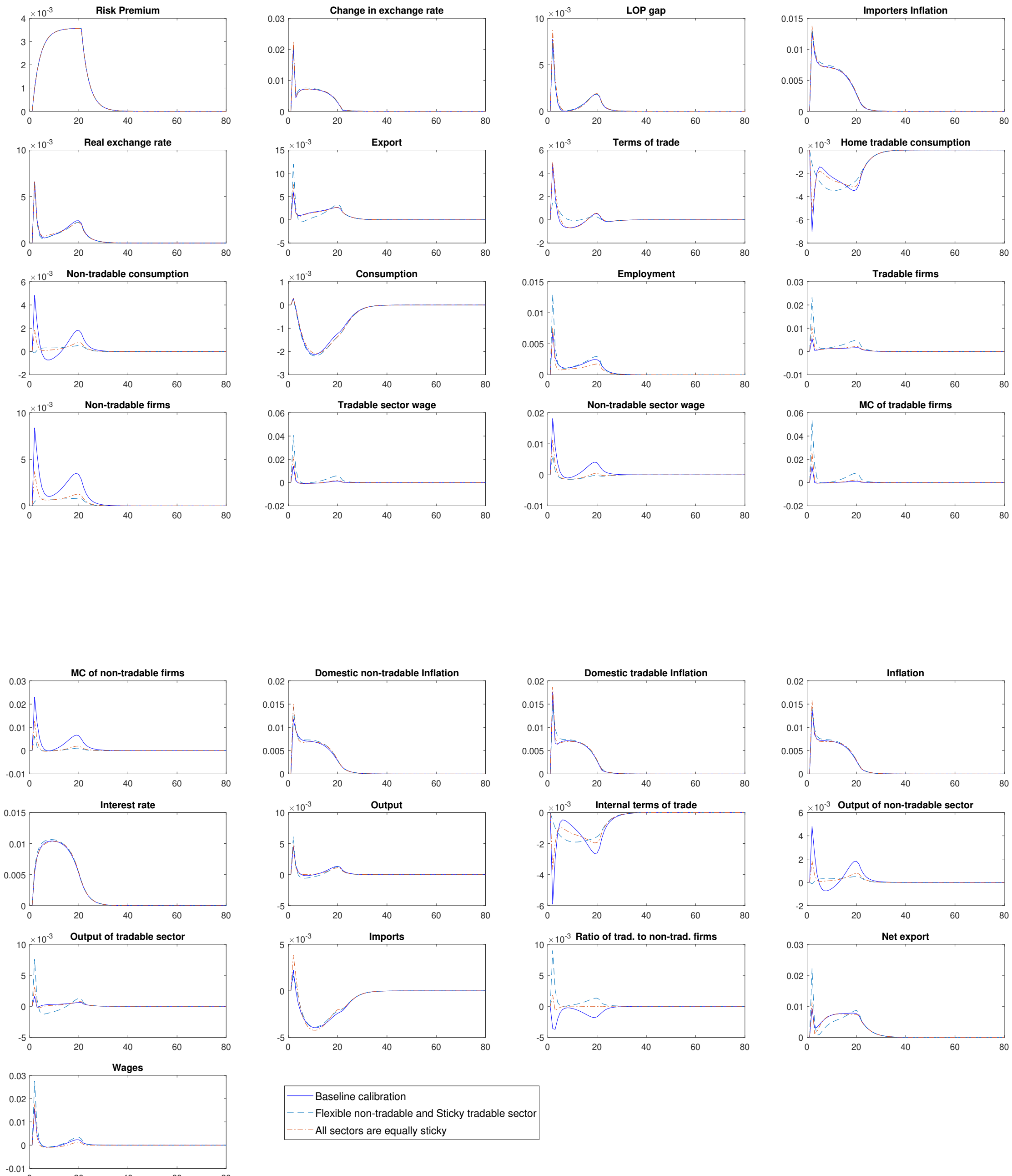


Figure 9: Exchange rate policy (sensitivity analysis)

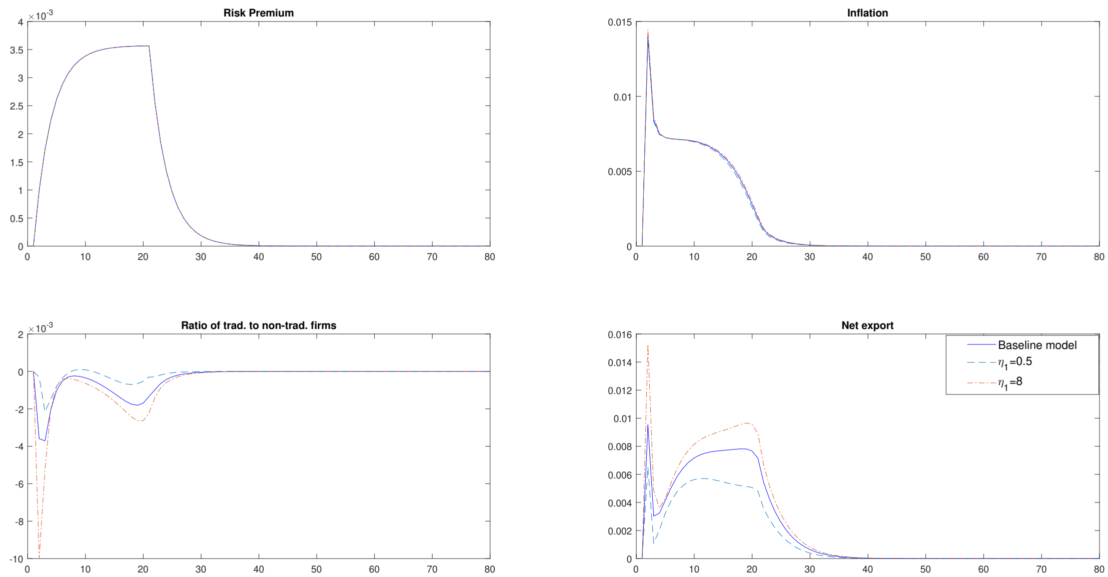


Figure 10: Exchange rate policy (sensitivity analysis)

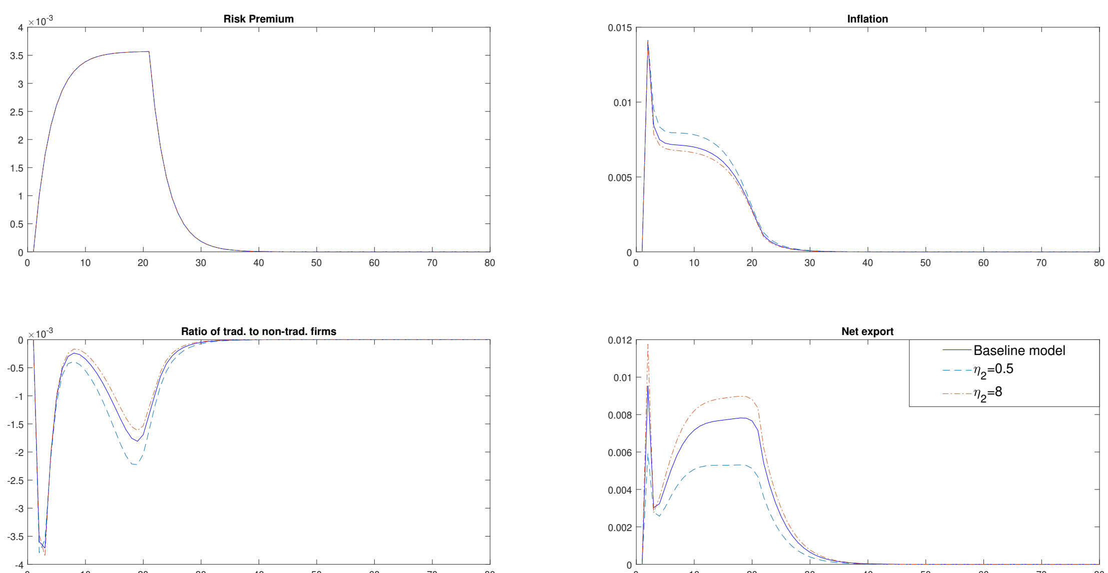


Figure 11: Exchange rate policy (sensitivity analysis)

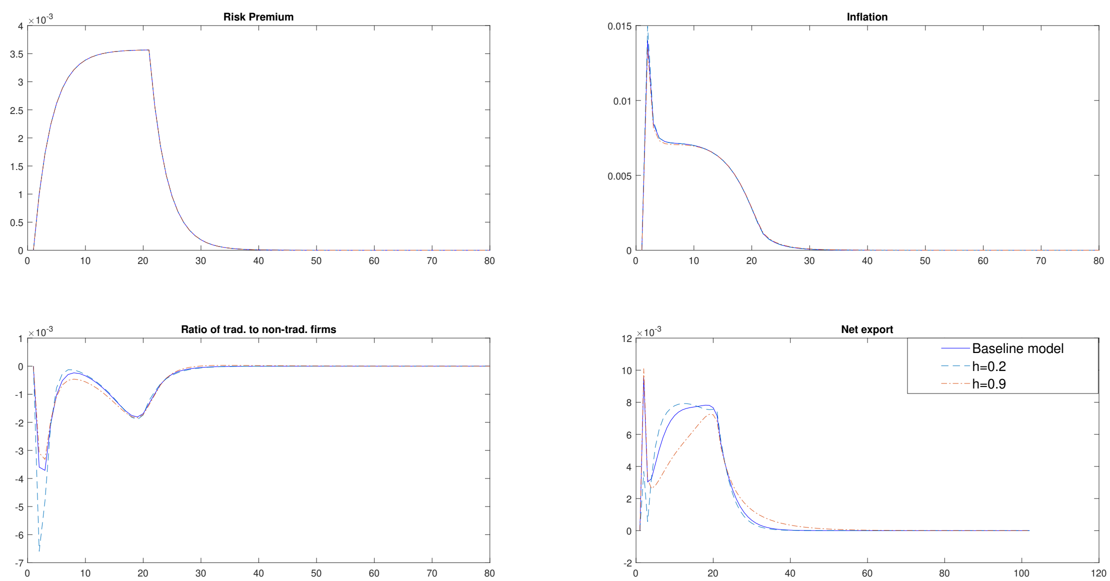
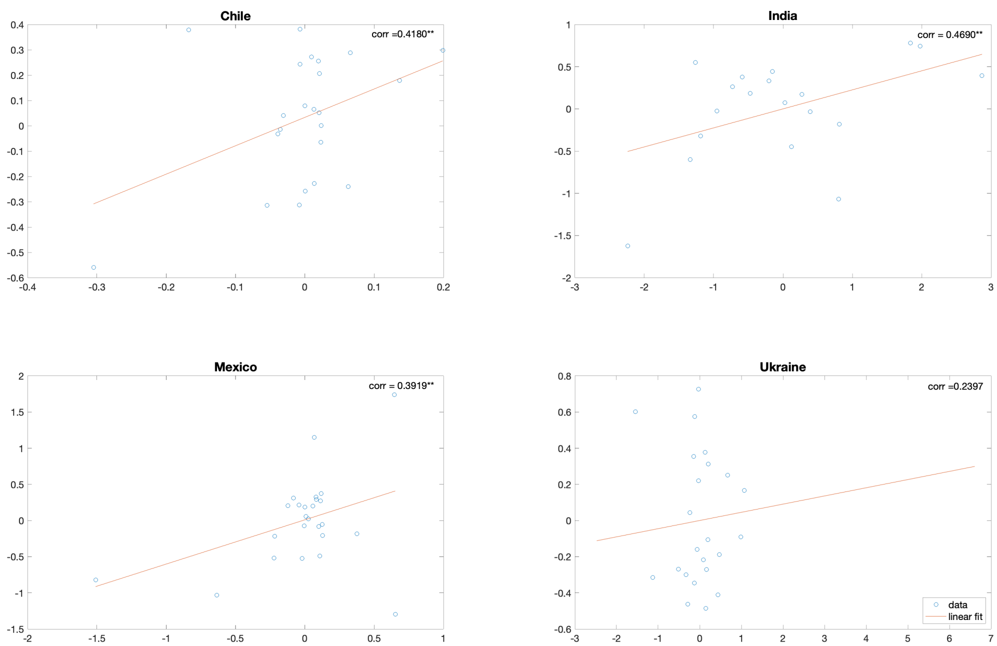


Figure 12: Exchange rate policy (sensitivity analysis)

8.5 Appendix 3. Empirical evidence



Note: Vertical axes represent the change in producer support estimate in agriculture as a percent in GDP.
Source: OECD (2021), Agricultural support (indicator). doi: 10.1787/6ea85c58-en (Accessed on 19 February 2021).
Horizontal axes shows the change in employment in agriculture (% of total employment) (modeled ILO estimate). Soucre: World Bank database.
** denote 5% statistical significance