The macroeconomic effects of market deregulation in the service sector*

Wataru Johdo [i]

Tokyo Keizai University

Abstract

This paper develops a small open economy model that incorporates a services sector and explores the consumption and welfare effects of deregulation of that sector. Our model is an extension of the new open economy macroeconomics model, which allows us to analyze the macroeconomic effects of deregulation more clearly. The study shows that deregulation in the services sector increases long-run service production and consumption and lowers the consumer price index in the long run, yet has no impact on short-run service production, consumption, and prices. Regarding welfare, deregulation in the home country always benefits that country.

Keywords: deregulation, service sector, small open economy, consumption, welfare

JEL Classification: E41, F12, F41, L11

* The author is grateful to two anonymous referees for many valuable comments and suggestions that improved the article. Financial support by Tokyo Keizai University is gratefully acknowledged.

i) Department of Economics, Tokyo Keizai University, 1-7-34, Minami-cho, Kokubunji-shi, Tokyo 185-8502, Japan. E-mail: johdo@tku.ac.jp

First received, September 13, 2023; Revision received, January 12, 2024; Accepted, February 22, 2024

1 Introduction

Understanding the macroeconomic implications of deregulation policy is an important policy issue for policymakers and macroeconomists. In general, because of entry restrictions and nontariff barriers, competitiveness in many service (or nontradable goods) markets is inevitably inferior to that in tradable goods markets, which face constant competitive pressures in today's globalized economy. Therefore, as emphasized by Cavelaars (2006), service markets, which have potential for improvement in competitiveness because of various entry constraints, should be an important policy target for policymakers responsible for promoting competition in each country.

However, although there are many studies on the effects of fiscal and monetary policies in the field of macroeconomics, no study has attempted to consider the macroeconomic effects of deregulation in a small open economy model in the new open economy macroeconomics (NOEM) literature.[1] In the NOEM literature, the relationship between policy shocks and aggregate economic activity has been studied extensively at the theoretical level (see, for example, Obstfeld and Rogoff 1995; Lane 1997; Betts and Devereux 2000a, 2000b; Fender and Yip 2000; Hau 2000; Caselli 2001; Corsetti and Pesenti 2001; Tille 2001; Ganelli 2003, 2005a, 2005b; Choi 2005; Chu 2005; Ganelli and Tervala 2010; Di Giorgio et al. 2015; Johdo 2015). However, these studies have only focused on how macroeconomic activity in each country is influenced by unanticipated demand side shocks such as monetary and fiscal policy shocks in one country.

The purpose of this paper is to consider how deregulation affects the macroeconomic variables in the framework of the small open economy model of Obstfeld and Rogoff (1995) with two sectors (tradable goods sector and service goods sector). From this simple analysis, the macroeconomic effects of deregulation policies can be shown more realistically and explicitly. The convenience of this approach is that we can jointly analyze the short- and long-run consequences of deregulation shocks simultaneously, which enables us to gain more realistic and detailed insights into the effectiveness of deregulation policies on the economy.

In a related study, Lane (1997) uses the two-sector small open economy

[1] The seminal contribution to the NOEM literature is Obstfeld and Rogoff (1995). For a survey of the NOEM models, see Lane (2001), Sarno (2001), and Lane and Ganelli (2003).

model of Obstfeld and Rogoff (1995) and examines how key macroeconomic variables and the exchange rate are influenced by monetary policy shocks. Cavallari (2001) and Lee and Chinn (2006) also take the two-sector small open economy model of Obstfeld and Rogoff (1995) (or Lane (1997)) and study how the current account and exchange rate are influenced by monetary policy shocks. Johdo (2013a) analyzes how the degree of consumption habits changes the response of welfare to monetary policy shocks based on the two-sector small open economy model of Obstfeld and Rogoff (1995) and Lane (1997). In addition, Johdo (2013b) studies the effects of a consumption tax rise based on the two-sector small open economy model of Obstfeld and Rogoff (1995) and Lane (1997).

However, few studies have analyzed the theoretical mechanisms of the macroeconomic effects of deregulation in the services sector in the above NOEM models. An exception is the work of Cavelaars (2006), which studies the macroeconomic effects of deregulation in the services sector on the exchange rate and output by extending the two-country NOEM model to include the services sector.[2] Cavelaars (2006) shows that an increase in the degree of competition in the services sector in a home country has negative spillover effects (negative pecuniary externalities) on the foreign country via terms of trade adjustments. Another exception is the study of Johdo (2019), which uses a two-country NOEM model that incorporates cross-border relocation of firms to analyze the international spillover effects of deregulation shocks in the services sector. In particular, that study shows that higher firm mobility between two countries weakens the effects of deregulation shocks on the exchange rate and consumption. However, no study has attempted to consider the macroeconomic effects of deregulation in the services sector in a small open economy model in the NOEM literature.

This paper investigates the impacts of deregulation on the macroeconomy by simplifying the two-country, two-sector model of Cavelaars (2006) to a small open economy model. We show explicitly various macroeconomic effects of deregulation policy. The convenience of this analysis is that we can analyze the short-run and long-run consequences of deregulation shocks simultaneously. In this paper, as in Cavelaars (2006), we focus on the degree of the elasticity of substitution between any two differentiated services as a

[2] In the two-country NOEM models, Hau (2000) and Evers (2006) have already developed a NOEM model including services.

mechanism of deregulation shocks. In addition, we use welfare criteria to evaluate whether the effects of deregulation in the services sector are positive or negative for the economy.

The main findings of this analysis are as follows: i) in the short run, a deregulation shock in the services sector has no effect on production, household consumption, and welfare; ii) however, in the long run, deregulation has positive effects on services production, household consumption, and welfare, and lowers the consumer price index; and iii) the larger the share of services in consumption utility, the larger the positive welfare effect of deregulation.

The remainder of this paper is structured as follows. Section 2 outlines the features of the model. Section 3 describes the equilibrium. In Sections 4 and 5, we examine the impacts of deregulation on short-run and long-run production, household consumption, and welfare. The final section summarises the findings and concludes.

2 The Model

Following Obstfeld and Rogoff (1995) and Lane (1997), we consider a small open economy with two sectors, a traded goods sector and a services (or nontraded goods) sector. The traded goods sector is characterised by a single homogeneous endowment, and the price of traded goods is determined in perfectly competitive world markets. The services sector is a monopolistically competitive market with differentiated goods. In this model, a unit mass of agents is characterised as both consumers and producers, where each agent produces a unit of services. The agents have perfect foresight, they derive their utility from consuming homogeneous traded goods and a group of differentiated services and from holding real money balances, and incur the cost of expending labor (or production) effort. The intertemporal objective of a typical agent at time 0 is to maximise the following lifetime utility:

$$U_0 = \sum_{t=0}^{\infty}\beta^t\left[\delta\log\gamma C_t^T + (1-\delta)\log C_t^N + \chi\log\frac{M_t}{P_t} - \frac{\eta}{2}y_t^N(i)^2\right], \qquad (1)$$

where $0 < \beta < 1$ is a constant subjective discount factor, $y^N_t(i)$ is the agent's output of services in period t, δ is the share of the consumption of traded goods ($(1-\delta)$ is the share of the consumption of services), C^T_t is consumption of the traded good, and C^N_t is composite services consumption, defined as:

$$C_t^N = \left(\int_0^1 C_t^N(i)^{(\theta-1)/\theta} di\right)^{\theta/(\theta-1)}, \tag{2}$$

where θ (> 1) is the elasticity of substitution between any two differentiated services and $C^N_t(i)$ is the consumption of service i. The third term in equation (1) represents real money balances (M_t/P_t), where M_t denotes nominal money balances held at the beginning of period $t+1$, and P_t is the total consumption price index, which is defined as:

$$P_t = \frac{P_t^{T\delta} P_t^{N(1-\delta)}}{\delta^\delta (1-\delta)^{1-\delta}}, \tag{3}$$

where P^N_t is the price index of services and is defined as:

$$P_t^N = \left(\int_0^1 P_t^N(i)^{1-\theta} di\right)^{1/(1-\theta)}, \tag{4}$$

and P^T_t is the domestic currency price of traded goods. Because there are no trade costs, the law of one price holds for traded goods; i.e., $P^T_t = \varepsilon_t P^{T*}_t$, where ε_t is the nominal exchange rate and P^{T*}_t is the exogenously determined world price. A typical agent faces the following budget constraint:

$$P_t^T B_{t+1} + M_t = P_t^T(1+r)B_t + M_{t-1} + P_t^N(i) y_t^N(i) + P_t^T y^T - P_t^N C_t^N - P_t^T C_t^T + T_t, \tag{5}$$

where B_{t+1} denotes real bonds denominated in traded goods in period $t+1$, r denotes the world real interest rate in traded goods on bonds that applies between periods $t-1$ and t, and T_t denotes lump-sum transfers from the government. We assume that all seignorage revenues derived from printing the national currency are rebated to the public, and the size of the population is normalized to unity. Hence, the government budget constraint is $M_t - M_{t-1} = T_t$. In addition, in this model, each agent is endowed with a constant amount of the traded good in each period. Therefore, as shown in equation (5), we can delete the subscript t from y^T_t; i.e., $y^T_t = y^T$, $\forall t$. At the first stage, agents maximise the consumption index (2) subject to a given level of expenditure on services $P_t^N C_t^N = \int_0^1 P_t^N(i) C_t^N(i) di$ by optimally allocating differentiated services. This static problem yields the following demand function for service *i*:

$$y_t^N(i) = \left(\frac{P_t^N(i)}{P_t^N} \right)^{-\theta} C_t^{NA}, \tag{6}$$

where $C^{NA}{}_t$ is aggregate services consumption. At the second stage, agents maximise (1) subject to (5). For simplicity, we assume $\beta(1 + r) = 1$. Then, the first-order conditions for this problem can be written as:

$$C_{t+1}^T = C_t^T, \tag{7}$$

$$C_t^N = \left(\frac{1-\delta}{\delta} \right) \left(\frac{P_t^T}{P_t^N} \right) C_t^T, \tag{8}$$

$$\frac{\delta}{C_t^T} = \chi \left(\frac{M_t}{P_t} \right)^{-1} \left(\frac{P_t^T}{P_t} \right) + \beta \left(\frac{P_t^T}{P_{t+1}^T} \right) \left(\frac{\delta}{C_{t+1}^T} \right), \tag{9}$$

$$y_t^N(i)^{(\theta+1)/\theta} = \left(\frac{(\theta-1)(1-\delta)}{\theta\eta} \right) \left(\frac{1}{C_t^N} \right) \left(C_t^{NA} \right)^{1/\theta}, \tag{10}$$

where equation (7) is the Euler equation for the consumption of traded goods, equation (8) shows the optimal condition for the allocation of traded goods and services, equation (9) is the optimal condition for money demand, and equation (10) is the labor–leisure trade-off condition. Finally, the terminal condition is $\lim_{\tau=\infty} (1/(1+r))^\tau \left(B_{t+\tau+1} + (M_{t+\tau}/P_{t+\tau}) \right) = 0$.

3 Steady-State Equilibrium

Henceforth, we assume that initial net foreign assets are zero ($B_0 = 0$). In the steady state, all exogenous variables are constant. Substituting equation

(8) into equation (10) and considering the symmetric equilibrium $C^N = y^N = C^{NA}$, we obtain:

$$C^N = y^N = \left(\frac{(\theta - 1)(1 - \delta)}{\theta \eta} \right)^{\frac{1}{2}}. \tag{11}$$

Equation (11) shows that all agents produce the same output of services.

4 A Log-Linearized Analysis

To examine the effects of an unanticipated deregulation shock, we solve a log-linear approximation of the system around the initial, zero-shock steady state. Following Obstfeld and Rogoff (1995) and Lane (1997), we assume nominal price rigidities under which the price of services in period t is predetermined at time $t - 1$. In addition, the price of services is assumed to be fully adjusted after one period. Therefore, as in Obstfeld and Rogoff (1995), in the long-run equilibrium, the price of services adjusts perfectly to the new steady-state value to be consistent with the optimal condition (10). For any variable X_t, we use $\hat{X}_t$ ($\hat{X}_{t+1}$) to denote the short-run (long-run) percentage deviation from the initial steady-state value. This implies that the short-run percentage deviation is proportional to the degree of nominal price rigidity. In what follows, we assume that the nominal money supply is held constant, so that $\widehat{M}_t = \widehat{M}_{t+1} = 0$.

We consider the effects of an unanticipated deregulation shock in the services sector.[3] Here, an unanticipated deregulation shock is defined as $\hat{\theta} > 0$.[4] In the short run, as the price of services is sticky, we obtain $\hat{P}_t^N = 0$. In this model, as assumed above, each agent is endowed with a constant amount of the traded good in each period. Therefore, as the consumption of traded goods remains constant in each period, we obtain $\hat{C}_t^T = \hat{C}_{t+1}^T = 0$. Furthermore, from equation (11), the long-run changes in services

[3] See the Appendix for detailed derivation of the effects of unanticipated deregulation shocks in the services sector.

[4] Here, the term "unanticipated deregulation shock" is used in this paper to indicate an exogenous shock at the initial steady state. In addition, our main results are not qualitatively different, even if we considered the cost of production as a policy variable for deregulation, that is, η instead of θ.

consumption and output are:

$$\hat{C}_{t+1}^{N} = \hat{y}_{t+1}^{N} = \frac{1}{2}\left(\frac{1}{\theta - 1}\right)\hat{\theta}. \tag{12}$$

Equation (12) shows that a deregulation shock in the services sector increases the long-run output and consumption of services.

By log-linearizing equations (8) and (9), and considering $\hat{P}_t^N = 0$ and $\hat{C}_t^T = 0$, we obtain $\hat{C}_t^N = \hat{P}_t^T$. This equation shows that the consumption of services is affected positively by the price of traded goods in the short run. In addition, with$\hat{P}_t^N = 0$, the short-run response of the total consumption price index is $\hat{P}_t = \delta \hat{P}_t^T$. Following Obstfeld and Rogoff (1995), in this model, we assume no speculative bubbles for prices of traded goods. Under this assumption, the prices of traded goods should be constant from the constant money supply. This implies $P_t^T = P_{t+1}^T$. Therefore, the short-run and long-run prices of traded goods are $\hat{P}_t^T = \hat{P}_{t+1}^T = 0$. This equation shows that a deregulation shock in the services sector has no effect on the short-run and long-run prices of traded goods. From the total consumption price index, we obtain $\hat{P}_{t+1} = \delta \hat{P}_{t+1}^T + (1-\delta)\hat{P}_{t+1}^N$. Furthermore, from equation (8), we obtain:

$$\hat{P}_{t+1}^{T} = \hat{P}_{t+1}^{N} + \hat{C}_{t+1}^{N}. \tag{13}$$

Substituting $\hat{P}_t^T = \hat{P}_{t+1}^T = 0$ into equation (13), we obtain $\hat{P}_{t+1}^N = -\hat{C}_{t+1}^N$. Hence, by combining $\hat{P}_{t+1} = \delta \hat{P}_{t+1}^T + (1-\delta)\hat{P}_{t+1}^N$, $\hat{P}_{t+1}^N = -\hat{C}_{t+1}^N$, $\hat{P}_t^T = \hat{P}_{t+1}^T = 0$, and equation (12), we obtain:

$$\hat{P}_{t+1} = (1-\delta)\hat{P}_{t+1}^{N} = -\frac{1}{2}\left(\frac{1-\delta}{\theta - 1}\right)\hat{\theta}. \tag{14}$$

Equation (14) implies that a deregulation shock in the services sector has a negative effect on the long-run total consumption price index.

Meanwhile, because the world price of traded goods is determined exogenously in the small open economy model and $P^T{}_t = \varepsilon_t P^T{}_t^*$ always holds, we obtain $\hat{P}_t^T = \hat{\varepsilon}_t$ in the short run. This implies that the price of traded goods reacts proportionately to the exchange rate. From $\hat{P}_t^T = \hat{\varepsilon}_t$ and $\hat{P}_t^T = \hat{P}_{t+1}^T = 0$, the short-run response of the exchange rate is given by $\hat{\varepsilon}_t = \hat{P}_t^T =$

0. This equation shows that a deregulation shock in the services sector has no effect on the price of traded goods and the nominal exchange rate. Therefore, from equations $\hat{P}_t = \delta \hat{P}_t^T$ and $\hat{\varepsilon}_t = \hat{P}_t^T = 0$, we obtain $\hat{P}_t = 0$. This equation shows that a deregulation shock in the services sector has no effect on the short-run response in the total consumption price index. Finally, from equations $\hat{C}_t^N = \hat{P}_t^T$ and $\hat{\varepsilon}_t = \hat{P}_t^T = 0$, we obtain:

$$\hat{C}_t^N = 0 . \tag{15}$$

Equation (15) shows that a deregulation shock in the services sector has no effect on the household's short-run consumption of services. Meanwhile, the price of services is fixed and the output of services is determined by demand. Therefore, from equation (6) and $P^N(i)/P^N = 1$, we obtain $\hat{y}_t^N = \hat{C}_t^N$. Thus, by linking this to equation (15), we obtain $\hat{y}_t^N = \hat{C}_t^N = 0$. This equation shows that a deregulation shock in the services sector has no effect on the short-run output of services.

Thus, as seen in equations (12) and (14), we see that a deregulation shock in the services sector increases the long-run output and consumption of services and lowers the long-run total consumption price index.

5 Welfare Analysis

Our interest here lies in exploring the welfare effects of deregulation shocks. By defining the real component of an agent's utility as U^R and recalling that $\hat{C}_t^T = \hat{C}_{t+1}^T = 0$, $\hat{y}_t^N = \hat{C}_t^N = 0$, and $\widehat{M}_t = \widehat{M}_{t+1} = 0$, we can rewrite equation (1) as:

$$\Delta U^R = \left(\frac{\beta}{1-\beta} \right) \left[(1-\delta) \hat{C}_{t+1}^N - \eta \left(y_0^N \right) \hat{y}_{t+1}^N \right], \tag{16}$$

where y_0^N denotes the initial steady-state output of services. The first term in brackets on the right-hand side of equation (16) reflects the welfare gain from an increase in the household's long-run consumption of services. The second term is the welfare loss from an increase in long-run labor effort in the services sector. Therefore, the impact of a deregulation shock on welfare is ambiguous. To determine the sign, the long-run results for services consumption and output can be used to derive the impact of an unanticipated deregulation shock on U^R. By substituting equations (11) and (12) into equation (16), we obtain:

$$\Delta U^R = \frac{1}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\delta}{\theta(\theta-1)}\right)\hat{\theta} > 0. \tag{17}$$

Therefore, ΔU^R is always positive. The real balance component of utility (defined as U^M) is:

$$\Delta U^M = -\frac{\chi}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\delta}{\theta-1}\right)\hat{\theta} > 0. \tag{18}$$

From equations (17) and (18), the overall welfare change from deregulation is:

$$\Delta U = \Delta U^R + \Delta U^M = \frac{1}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\delta}{\theta-1}\right)\left(\frac{1}{\theta}+\chi\right)\hat{\theta} > 0. \tag{19}$$

Equation (19) shows that the overall welfare effect of deregulation is positive. This implies that domestic households gain equally from an unanticipated domestic deregulation shock. As seen in equation (19), the lower the value of the elasticity of substitution between any two differentiated services θ, the larger are the initial monopoly distortion in the services sector and the welfare gain from a deregulation shock. In addition, from equation (19), the larger the share of services in consumption utility, the larger is the positive welfare effect of deregulation.[5]

6 Conclusion

In this paper, we used a simplified two-sector small open economy model to consider how various macroeconomic variables respond to deregulation shocks in the services sector. From this analysis, we succeeded in showing

[5] In equation (23), $(1-\delta)$ is the share of the consumption of nontraded goods in the utility function.

explicitly the macroeconomic effects of deregulation policy shocks. The main finding of this analysis is as follows. The deregulation shock in the services sector increases long-run services production and consumption and lowers the long-run total consumption price index, while it has no effect on the short-run total consumption price index, short-run services production, and consumption.

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Appendix

Long-run equilibrium conditions

We derive the long-run equilibrium conditions of this model. By log-linearizing the model around the initial, zero-shock steady state with $B_0 = 0$, we obtain the following equations that characterize the long-run equilibrium of the system:

$$\hat{P}^T_{t+1} = \hat{M}_{t+1} - \hat{C}^T_{t+1} \tag{A.1}$$

$$\hat{C}^N_{t+1} = \hat{P}^T_{t+1} - \hat{P}^N_{t+1} + \hat{C}^T_{t+1} \tag{A.2}$$

$$\left(\frac{\theta+1}{\theta}\right)\hat{y}^N_{t+1} = \left(\frac{1}{\theta-1}\right)\hat{\theta} + \left(\frac{1-\theta}{\theta}\right)\hat{C}^N_{t+1} \tag{A.3}$$

$$\delta\hat{C}^T_{t+1} + (1-\delta)\left(\hat{P}^N_{t+1} - \hat{P}^T_{t+1}\right) + (1-\delta)\hat{C}^N_{t+1} = r\delta\hat{B}_{t+1} + (1-\delta)\left(\hat{P}^N_{t+1} - \hat{P}^T_{t+1}\right) + (1-\delta)\hat{y}^N_{t+1} + \delta\hat{y}^T_{t+1} \tag{A.4}$$

$$\hat{y}^N_{t+1} = \theta\left(\hat{P}^N_{t+1} - \hat{P}^N_{t+1}(i)\right) + \hat{C}^{NA}_{t+1} \tag{A.5}$$

$$\hat{P}_{t+1} = \delta\hat{P}^T_{t+1} + (1-\delta)\hat{P}^N_{t+1} \tag{A.6}$$

$$\hat{\varepsilon}_{t+1} = \hat{P}^T_{t+1} \tag{A.7}$$

where $\hat{B}_{t+1} \equiv dB_{t+1}/C^T_0$, with $C^T{}_0$ being the initial value of traded goods consumption.[6] The equations in (A.1) correspond to the money-demand equation. Equation (A.2) represents the optimal condition for the allocation of traded goods and services, equation (A.3) is the labor–leisure trade-off condition, equation (A.4) represents the long-run change in incomes (returns on real bonds and real incomes in traded goods and services), which equal the long-run changes in consumption. The equation in (A.5) represents the demand function for services. The equation in (A.6) is the price index equation. Equation (A.7) is the purchasing power parity equation.

[6] In this model, we scale bond holdings by using the initial level of traded goods consumption, $C^T{}_0$.

Short-run equilibrium conditions

We derive short-run equilibrium conditions of this model. By log-linearizing the model around the initial, zero-shock steady state with $B_0 = 0$, we obtain the following equations that characterize the short-run equilibrium of the system:

$$\hat{C}_{t+1}^{T} = \hat{C}_{t}^{T} \tag{A.8}$$

$$\hat{M}_{t} - \hat{P}_{t} = \hat{C}_{t}^{T} + \hat{P}_{t}^{T} - \hat{P}_{t} + \left(\frac{\beta}{1-\beta}\right)\left(\hat{P}_{t}^{T} - \hat{P}_{t+1}^{T}\right) \tag{A.9}$$

$$\hat{C}_{t}^{N} = \hat{P}_{t}^{T} - \hat{P}_{t}^{N} + \hat{C}_{t}^{T} \tag{A.10}$$

$$\delta\hat{C}_{t}^{T} + (1-\delta)\left(\hat{P}_{t}^{N} - \hat{P}_{t}^{T}\right) + (1-\delta)\hat{C}_{t}^{N} = \delta\hat{B}_{t+1} + (1-\delta)\left(\hat{P}_{t}^{N} - \hat{P}_{t}^{T}\right) + (1-\delta)\hat{y}_{t}^{N} + \delta\hat{y}_{t}^{T} \tag{A.11}$$

$$\hat{y}_{t}^{N} = \theta\left(\hat{P}_{t}^{N} - \hat{P}_{t}^{N}(i)\right) + \hat{C}_{t}^{NA} \tag{A.12}$$

$$\hat{P}_{t}^{N} = \hat{P}_{t}^{N}(i) \tag{A.13}$$

$$\hat{P}_{t} = \delta\hat{P}_{t}^{T} + (1-\delta)\hat{P}_{t}^{N} \tag{A.14}$$

$$\hat{\varepsilon}_{t} = \hat{P}_{t}^{T} \tag{A.15}$$

where the equation in (A.8) is the Euler equation for the consumption of traded goods. The equation in (A.9) describes equilibrium in the money markets in the short run. The equation in (A.10) represents the optimal condition for the allocation of traded goods and services. The equation in (A.11) is linearized short-run current account equation. The equation in (A.12) represents the demand function for services. Equation (A.13) is the price index of services. Equation (A.14) is the price index equation. Equation (A.15) is the purchasing power parity equation.

Consumption and price effects of deregulation

In this model, as prices of traded goods are sticky in the short run, we can set nominal prices of services as $\hat{P}_t^N(i) = 0$ in the above short-run log-linearized equations. Therefore, from equation (A.13)

$$\hat{P}_t^N = \hat{P}_t^N(i) = 0 \tag{A.16}$$

In this model, each agent is endowed with a constant amount of the traded good in each period and consumes them all. Therefore, we obtain

$$\hat{C}_t^T = \hat{C}_{t+1}^T = 0 \tag{A.17}$$

Substituting equations (A.16) and (A.17) into equation (A.10) yields:

$$\hat{P}_t^T = \hat{C}_t^N \tag{A.18}$$

Substituting $\widehat{M}_t = \widehat{M}_{t+1} = 0$ and equation (A.17) into equation (A.9) yields:

$$-\hat{P}_t^T = \left(\frac{\beta}{1-\beta}\right)\left(\hat{P}_t^T - \hat{P}_{t+1}^T\right) \tag{A.19}$$

Substituting equation (A.16) into equation (A.14) yields:

$$\hat{P}_t = \delta \hat{P}_t^T \tag{A.20}$$

Following Obstfeld and Rogoff (1995), in this model, we assume no speculative bubbles for prices of traded goods. Under this assumption, the prices of traded goods should be constant from the constant money supply. This implies $P_t^T = P_{t+1}^T$. Therefore, we obtain

$$\hat{P}_t^T = \hat{P}_{t+1}^T = 0 \tag{A.21}$$

Substituting equation (A.17) into equation (A.2) yields:

$$\hat{P}_{t+1}^T = \hat{P}_{t+1}^N + \hat{C}_{t+1}^N \tag{A.22}$$

From equations (A.6), (A.21) and (A.22), we obtain

$$\hat{P}_{t+1} = -(1-\delta)\hat{C}^{N}_{t+1} \tag{A.23}$$

In this model, the size of population is normalized to unity. Therefore, we obtain $\hat{C}^{NA}_{t+1} = \hat{C}^{N}_{t+1}$. Substituting $\hat{C}^{NA}_{t+1} = \hat{C}^{N}_{t+1}$ and $\hat{P}^{N}_{t+1} = \hat{P}^{N}_{t+1}(i)$ into equation (A.5) yields:

$$\hat{y}^{N}_{t+1} = \hat{C}^{N}_{t+1} \tag{A.24}$$

Substituting equation (A.24) into equation (A.3) yields:

$$\hat{C}^{N}_{t+1} = \hat{y}^{N}_{t+1} = \frac{1}{2}\left(\frac{1}{\theta-1}\right)\hat{\theta} \tag{A.25}$$

Equation (A.25) is equivalent to equation (12). Substituting equation (A.25) into equation (A.23) yields:

$$\hat{P}_{t+1} = -\frac{1}{2}\left(\frac{1-\delta}{\theta-1}\right)\hat{\theta} \tag{A.26}$$

Equation (A.26) is also equivalent to equation (14). From equations (A.7), (A.15), and (A.21), we obtain

$$\hat{\varepsilon}_{t} = \hat{\varepsilon}_{t+1} = 0 \tag{A.27}$$

Substituting equations (A.16) and (A.21) into equation (A.14) yields:

$$\hat{P}_{t} = 0 \tag{A.28}$$

Substituting equation (A.21) into equation (A.18) yields:

$$\hat{C}^{N}_{t} = 0 \tag{A.29}$$

Equation (A.29) is also equivalent to equation (15). Substituting $\hat{C}^{NA}_{t} = \hat{C}^{N}_{t}$ and $\hat{P}^{N}_{t} = \hat{P}^{N}_{t}(i)$ into equation (A.12) yields:

$$\hat{y}^{N}_{t} = \hat{C}^{N}_{t} \tag{A.30}$$

From equations (A.29) and (A.30), we obtain

$$\hat{y}_t^N = 0 \tag{A.31}$$

Welfare effects of deregulation

The real component of an agent's utility (defined as U^R) is

$$\Delta U^R = \delta\hat{C}_t^T + (1-\delta)\hat{C}_t^N - \eta\left(y_0^N\right)\hat{y}_t^N + \left(\frac{\beta}{1-\beta}\right)\left[\delta\hat{C}_{t+1}^T + (1-\delta)\hat{C}_{t+1}^N - \eta\left(y_0^N\right)\hat{y}_{t+1}^N\right] \tag{A.32}$$

The real balance component of utility (defined as U^M) is

$$\Delta U^M = \chi\left(\hat{M}_t - \hat{P}_t\right) + \left(\frac{\beta}{1-\beta}\right)\chi\left(\hat{M}_{t+1} - \hat{P}_{t+1}\right) \tag{A.33}$$

Considering that $\hat{C}_t^T = \hat{C}_{t+1}^T = 0$ and $\hat{y}_t^N = \hat{C}_t^N = 0$, we can rewrite equation (A.32) as

$$\Delta U^R = \left(\frac{\beta}{1-\beta}\right)\left[(1-\delta)\hat{C}_{t+1}^N - \eta\left(y_0^N\right)\hat{y}_{t+1}^N\right] \tag{A.34}$$

Considering that $\widehat{M}_t = \widehat{M}_{t+1} = 0$ and equation (A.28), we can rewrite equation (A.33) as

$$\Delta U^M = -\left(\frac{\beta}{1-\beta}\right)\chi\hat{P}_{t+1} \tag{A.35}$$

From equation (11), the steady-state output of services is

$$y^N = \left(\frac{(\theta-1)(1-\delta)}{\theta\eta}\right)^{\frac{1}{2}} \tag{A.36}$$

Substituting equations (A.25) and (A.36) into equation (A.34) yields:

$$\Delta U^R = \frac{1}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\delta}{\theta(\theta-1)}\right)\hat{\theta} > 0 \tag{A.37}$$

Equation (A.37) is equivalent to equation (17). Substituting equation (A.26) into equation (A.35) yields:

$$\Delta U^{M} = -\frac{\chi}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\delta}{\theta-1}\right)\hat{\theta} > 0 \tag{A.38}$$

Equation (A.38) is equivalent to equation (18). From equations (A.37) and (A.38), the overall welfare change from deregulation is

$$\Delta U = \Delta U^{R} + \Delta U^{M} = \frac{1}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\delta}{\theta-1}\right)\left(\frac{1}{\theta}+\chi\right)\hat{\theta} > 0 \tag{A.39}$$

Equation (A.39) is equivalent to equation (19).