

## Firm Liquidation and Economic Crisis under Unexpected Exchange Rate Shock\*

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This paper studies the causes, mechanisms and consequences of decreasing firm value and welfare loss in an economy under a fixed exchange rate regime when there is an unexpected appreciation in domestic currency. We also study the possible economic crisis caused by the exchange rate shock. We consider the established production capacity as well as the training of firm-specific labors before production to obtain that unexpected appreciation in domestic currency leads to unemployment of firm workers as well as a decrease in the firm's output and revenue. Furthermore, when the exchange rate appreciates to a certain degree, it is likely to induce economic crisis—firms will stop production completely which will not only decrease the firm's value, but also create a greater loss of social welfare due to the waste of existing capacity and human capital in the economy. Our study also implies that when an economy shifts from a fixed exchange rate regime to a more flexible one, government could adopt gradual reform policies and partial deregulation of the exchange rate to reduce or prevent social welfare loss when domestic currency faces appreciation pressure.

*Key Words:* Exchange shocks; Firm liquidation; Financial crisis.

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## 1. INTRODUCTION

The early 2008 economic crisis in Vietnam makes it clear that even a promising economy facing appreciation pressure could be in danger of experiencing economic crisis if its exchange rate regime fails to maintain economic stability. In the example of Vietnam, the nominal fixed exchange rate has been maintained for a long time, and years of trade surplus has increased the government's foreign exchange reserve which caused an accumulation in domestic money supply and eventually lead to inflation and economic crisis. During this time, inflation caused the real exchange rate of Vietnam to appreciate rapidly for a short time, and then it depreciated significantly during the economic crisis.

In fact, Vietnam is not the first economy to collapse under the pressure of appreciation due to problems in the economic policy. Even though the mechanism behind the economic crisis might be different, Japan in the latter half of the last century also experienced depression under rapid appreciation of domestic currency and fell from a promising economy to decades of economic stagnancy.

Meanwhile, successful examples exist. For instance, in the last decade of the 20th Century, countries like Chile, Israel and Poland successfully shifted from a fixed exchange rate regime to a more flexible one under the pressure of appreciation (Eichengreen, et al., 1998, Otker-Robe, et al., 2007).

The examples above all share the same features: when a country with a fixed exchange rate regime faces a big pressure from appreciation in domestic currency, it will experience a huge economic shock and crisis if this pressure is released rapidly during a short time, no matter whether it is through direct appreciation in nominal exchange rate or indirect appreciation in the real exchange rate. By contrast, economic crisis could be prevented if the government intervenes through proper economic policy and gradually alleviates the appreciation pressure.

These observations demand further studies in the detailed mechanism of economic crisis caused by exchange rate shock and the positive role played by government given the fixed exchange rate regime adopted by the economy.

From early on, there have been large volumes of research focusing on the mechanism of economic crisis under a fixed exchange rate regime. After the financial crisis at the end of the 20th Century in the emerging economies of Latin American countries and East Asia, Krugman and Rotemberg (1992), Cole and Kehoe (1996) and Obstfeld (1996) have studied the transition of the exchange rate regime in the context of financial crisis. However, these studies mainly focus on how speculation of foreign exchange market leads to a collapse in domestic currency, emphasizing behaviors in the exchange

market while overlooking the reactions and adjustment of the economy toward exchange rate shock. Therefore, analysis about the mechanism of economic crisis is still scant.

Eichengreen and Masson (1998), Otker-Robe, et al. (2007) conducted empirical research on the reform of exchange rate regimes based on reform experiences in the above countries with the main focuses on the macroeconomic, finance and institutional environments during shifts of the exchange rate regime. Their major conclusions are: The gradual exchange rate reform gains time for the economy to establish and achieve new macroeconomic policy as well as to learn to operate policy instruments and develop sufficient financial systems and financial instruments, which allow the economy to develop smoothly.

This paper studies how an exogenous exchange rate shock would affect the industries in an economy with a fixed exchange rate when the domestic currency faces the pressure of appreciation.

In order to seek answers to this question, this paper establishes a three-stage firm competition model in a small open economy, taking a micro-instead of macro-economic view to study issues in the exchange rate. There are three stages in a firm's production process: in the first stage, firms raise funds for production; in the second stage, firms build up firm-specific physical and human capital capacity; and in the third stage, firms make their production decision based on the existing physical and human capital capacity, i.e., decide upon the quantity of raw material and skilled workers required.

This paper mainly focuses on two important features in an economy. The first is the firm-specific production capacity. The firm-specific physical capacity has been studied and applied widely in Industrial Organization and related fields (Kreps and Scheinkman, 1983), while firm-specific human capital capacity also has to be considered to better fit the reality. Human capital capacity in this model refers to specific skills needed by most workers in modern manufacturing industries. Human capital capacity is first established through education at school and training from career service institutions; second, and more importantly, it comes from pre-service training by firms and the experiences acquired by workers during production. As a result, after workers become familiar with the environment and production process of a firm, it will be very difficult for them to find satisfying jobs elsewhere if they get fired. The technical experiences acquired before cannot be applied to the new environment and it is very costly to study new technologies suitable to the new firm.

The second feature is the rigid nominal price of labor in the economy. Since Keynes introduced rigid nominal wage in *The General Theory* (1936) to explain the Great Depression in the 1930's, rigid nominal wage has been a controversial issue in Economics (Gray, 1976, Fischer, 1977). Economic

researchers have been seeking reasonable explanations for rigid nominal wage until the very last of the 20th Century, and rigid nominal wage is still a common phenomenon in contemporary time. The assumption of a rigid nominal wage in this paper is consistent with the assumption of firm-specific human capital. According to the foregoing analysis, if workers have little choice after they are hired other than to become firm-specific human capital, they are very likely to be held up by the firm at the second stage of production. Therefore, firms often make the promise when signing contracts with workers that nominal wage will stay fixed. Thus, under rigid nominal wage, the economy is unable to adjust the wage level when relative prices change because of exchange rate shock. Hence, the rigid nominal wage leads to conflict between a firm's optimal choice and the socially efficient choice.

Given the two conditions above, this paper first analyzes firm behavior under the fixed exchange rate regime. The capacity built by the firm would be consistent with its succeeding output plan under stable price, so that the firm's behavior in this model would be similar to that described in neoclassical economics.

Next, we use unexpected changes in the exchange rate to represent a shock to the fixed exchange rate regime, and study the corresponding adjustment in firm decision and the economy. When the exchange rate changes, firms face new relative prices at the second stage of production, and must adjust their production plan accordingly. Since firms only maximize their own profits when making decisions, their production decisions will be different from the socially efficient resource allocation when there is a shock to the exchange rate. The unused human capital capacity refers to those skilled workers who are unemployed, which causes a huge waste of human resource. The loss caused by exchange rate shock increases with the change in exchange rate, and may lead to a breakdown of the entire industry when it reaches a certain benchmark.

The structure of the paper is as follows: The second part will describe the basic framework of the model. In the third part, we analyze firms' competition and economic equilibrium under a fixed exchange rate regime, introduce an unexpected exchange rate shock into the model, and discuss the firm's optimal strategy and society's optimal production arrangement accordingly. The fourth part discusses the means which can be used to mitigate the exchange rate shock in the framework we have developed. The fifth part is the conclusion.

## 2. BASIC MODEL

We assume a small open economy in which firms produce homogenous tradable products which can be sold in the international market. We design

the model mainly from the point of view of individual firms, since their behaviors are essential to the structure of the model.

### 2.1. The Technology Constraint: Production Function

We assume all firms adopt the same technology in production. Consider a typical firm  $j$  in the economy which invests physical material  $K$  and labor  $L$  in order to produce product  $Y$ . It is required that the firm should first build up production capacities in connection with different factors. To be specific, the firm should build up physical capacity  $S$  in order to input material  $K$ ; it should also acquire a corresponding number of workers with firm-specific production skills if it is to input  $L$  amount of labor, i.e., build up human capital capacity  $H$  in advance. We assume that the capacity established is firm-specific, i.e., a firm only has access to the capacity built up by itself but not by other firms. Therefore, let  $Y_j$  denote the output of firm  $j$ ,  $S_j$  and  $H_j$  denote its production capacity, and  $K_j$  and  $L_j$  denote its input factors, then we have the production function of a firm subject to firm-specific production capacity as follows:

$$Y_j = AK_j^\alpha L_j^{1-\alpha}, \quad s.t. K_j \leq S_j, L_j \leq H_j$$

### 2.2. The Market Constraint: Cost and Profit

The international price is measured in US dollars. We assume the economy pegs its exchange rate with US dollars, and the nominal exchange rate is  $e$  between the domestic currency and US dollars using direct quotation.

According to the assumptions in 2.1, firm  $j$  first needs to incur the cost of production capacity,  $S_j$  and  $H_j$ , and then input factors  $K_j$  and  $L_j$ . Assume the material for building  $S$  and  $K$  are imported from the foreign market at the price of  $c_S$ ,  $c_K$  dollars. Given the assumption of a small open economy, firm  $j$ 's cost functions  $C(S_j)$  and  $C(K_j)$  measured in US dollars are as follows:

$$C_S(S_j) = c_S S_j, C_K(K_j) = c_K K_j$$

We assume there is no mobility of labor between countries so that labor supply can only come from the domestic labor market. Specifically, we assume a competitive raw labor market in the economy which supplies  $L_0$  amount of unskilled workers in total. Establishing human capital capacity means the firm signs contracts with a certain number of potential labors and turns them into firm-specific skilled labor through training. The labor input  $L$  is the actual amount of skilled workers used in production. Hence a typical contract in the labor market contains two components of price: one is the wage paid to unskilled labors when the firm builds up its human capital capacity, and the other one is the wage of skilled workers used during production. The prices are measured in domestic currency. Because

we assume that the labor market is competitive, use  $w_H$  and  $w_L$  to denote the prices of human capital capacity and labor input respectively, then the labor cost of firm  $j$  measured in domestic currency is as follows:

$$C_H(H_j) = w_H H_j, C_L(L_j) = w_L L_j$$

The firm needs a sufficient amount of funds in order to pay for its production capacity and input factors. Assume the capital market in the economy is closed so that firms can only raise funds from the domestic capital market, and assume the total wealth endowment in the economy is  $W_0$  measured in domestic currency. The capital market is competitive, and let  $r$  denote the nominal price of domestic currency.

We assume the product can be traded in the international market at  $P$  dollars per unit, so that the firm gets  $PY_j$  dollars of revenue by selling product  $Y_j$  given the assumption of a small economy.

### 2.3. Firm Operation: Sequence of Competition

Now we study firm competition. We consider only one period of firm operation and divide it into three stages: Stage 0, Stage 1 and Stage 2.

Firms raise funds at Stage 0. At this stage, firms can raise all the capital they need for production through the domestic capital market at the price  $r$ . The capital market will close after this stage and firms will be unable to raise additional capital henceforth. Therefore, the domestic capital market reaches equilibrium at Stage 0. Let  $W_{j0}$  denote the fund raised by firm  $j$  at Stage 0, measured in domestic currency.

Firms build up production capacity at Stage 1. At this stage, firm  $j$  builds up its physical capacity  $S_j$  and signs contracts with  $H_j$  number of unskilled labors on the domestic labor market, thereby determining labor price  $w_H$  and  $w_L$ . The contracted unskilled labors are trained by the firm to become skilled workers. After Stage 1, the labor market will close and firm  $j$  can neither introduce more labors nor increase its physical capacity  $S_j$ . Therefore, the labor market reaches equilibrium at Stage 1.

Firms need to use part of their funds to build up production capacity. Let  $W_{j1}$  denote the surplus funds of firm  $j$  at the end of Stage 1, and let  $e_1$  denote the exchange rate at Stage 1, then the budget constraint of firm  $j$  at Stage 1 is:

$$e_1 c_S S_j + w_H H_j + W_{j1} = W_{j0}$$

Firms produce, sell and settle up at Stage 2. First, firms choose the optimal input of factors under the constraint of the established capacity and budget. Let  $W_{j1}$  denote the fund held by firm  $j$  at the end of Stage 1 and assume firm  $j$  holds the fund in US dollars with no interest, then  $W_{j1}$  is the maximum investment of firm  $j$  on production capacity at Stage 2. Let  $W_{j2}$  denote the surplus funds when production is finished, and let  $e_2$

denote the exchange rate at Stage 2, then we have the budget constraint of firm  $j$  at Stage 2:

$$e_2 c_K K_j + w_L L_j + W_{j2} = W_{j1}$$

When production is finished, the firm immediately sells its products on the international market and earns  $PY_j$ . The earnings converted into domestic currency at the exchange rate  $e_2$  plus the surplus fund  $W_{j2}$  equal firm  $j$ 's total revenue, i.e., its price at the end of the period. Firm  $j$  needs to pay back  $rW_{j0}$  to the initial fund provider, and the remainder is the firm's profit.

### 3. ANALYSIS

We first study economic equilibrium and firm behavior under a fixed exchange rate regime. Next, we introduce unexpected changes in the exchange rate to observe the firm's reaction to unexpected exchange rate shock, and further discuss changes in social welfare caused by the shock. We standardize the capacity price and factor price for the sake of convenience:

$$c_S = c, c_K = 1 - c, w_H = cw, w_L = (1 - c)w$$

#### 3.1. Competition and Equilibrium under Fixed Exchange Rate Regime

In this section, we study firm competition under a fixed exchange rate regime. In order to capture the essentials under a fixed exchange rate regime, we assume that  $e_1 = e_2 = e$ , and that all firms can perfectly anticipate the exchange rate and other prices. Under this assumption, firms will make the optimal production decisions in order to maximize their values. We use backward induction to determine the firm's optimal choices at different stages, and we begin with the firm's decision at Stage 2.

At Stage 2, given the product price  $p$ , the labor price  $w$ , the exchange rate  $e$ , the firm's capacity investment  $S_j$ ,  $H_j$ , and the surplus fund  $W_{j1}$ , the firm maximizes its value under technology and market constraints:  $ePAK_j^\alpha L_j^{1-\alpha} + W_{j2}$ . We denote the firm's maximum value function at Stage 2 by  $V_{j2}(S_j, H_j, W_{j1}, e)$ . In order to achieve it, the firm must choose the optimal production plan  $K_j^*$ ,  $L_j^*$ ,  $W_{j2}^*$ :

$$\begin{aligned} V_{j2}(S_j, H_j, W_{j1}, e) &= \max_{K_j, L_j, W_{j2} \geq 0} ePAK_j^\alpha L_j^{1-\alpha} + W_{j2} \\ &s.t. K_j \leq S_j, L_j \leq H_j \\ &e(1-c)K_j + (1-c)wL_j + W_{j2} = W_{j1} \end{aligned} \quad (P1)$$

Solve this problem to get  $K_j^*$ ,  $L_j^*$ ,  $W_{j2}^*$  and  $V_{j2}(S_j, H_j, W_{j1}, e)$ .

At Stage 1, given prices  $p$ ,  $w$ ,  $e$ , and initial fund  $W_{j0}$  raised by the firm, and let  $V_{j1}(W_{j0}, e)$  denote the maximum value function of firm  $j$  at this stage, the firm chooses the optimal production capacity  $S_j$ ,  $H_j$  and fund  $W_{j1}$  which satisfy

$$\begin{aligned} V_{j1}(W_{j0}, e) &= \max_{S_j, H_j, W_{j1} \geq 0} V_{j2}(S_j, H_j, W_{j1}, e) & (P2) \\ \text{s.t. } ec_S S_j + w_H H_j + W_{j1} &= W_{j0} \end{aligned}$$

Solving the problem we get the firm's best response  $S_j^*$ ,  $H_j^*$ ,  $W_{j1}^*$  and the value function  $V_{j1}(W_{j0}, e)$ :

LEMMA 1. *Under a fixed exchange rate regime, given exchange rate  $e$ , price  $w$ ,  $P$  and firm  $j$ 's initial fund  $W_{j0}$ , the firm's optimal choice is  $S_j^* = K_j^* = e^{-1}\alpha W_{j0}$ ,  $H_j^* = L_j^* = w^{-1}(1 - \alpha)W_{j0}$ .*

Firm  $j$ 's value function is  $V_{j1}(W_{j0}, e) = \left[\frac{e(1-\alpha)}{w}\right]^{1-\alpha} \alpha^\alpha P A W_{j0}$  when it produces according to the optimal choice. Hence, given the assumption of a competitive capital market, the equilibrium capital price of the economy at Stage 0 can only be  $\left[\frac{e(1-\alpha)}{w}\right]^{1-\alpha} \alpha^\alpha P A$ . Meanwhile, for the labor market to clear, the equilibrium wage should be  $w = (1 - \alpha) \frac{W_0}{L_0}$ . Hence we have Proposition 1:

PROPOSITION 1. *Under a fixed exchange rate regime, given exchange rate  $e$ , the capital price  $r = \left[\frac{eL_0}{W_0}\right]^{1-\alpha} \alpha^\alpha P A$ , and labor price  $w = (1 - \alpha) \frac{W_0}{L_0}$  at equilibrium, any firm is able to match its factor input with production capacity, i.e.,  $\forall j, S_j = K_j, H_j = L_j$ .*

This conclusion is intuitive. Since production capacity is established at a cost, firms will exhaust all production capacity when the exchange rate is fixed. In fact, the conclusion holds in the environment of a floating exchange rate without any uncertainty.

### 3.2. Unexpected Exchange Rate Shock

We continue the discussion based on the foregoing conclusions. Under a fixed exchange rate  $e$ , labor price is set at  $w = (1 - \alpha) \frac{W_0}{L_0}$  at the end of Stage 1, and firm  $j$  with initial fund  $W_{j0}$  builds up production capacity  $S_j = e^{-1}\alpha W_{j0}$ ,  $H_j = w^{-1}(1 - \alpha)W_{j0}$ . The surplus fund is  $W_{j1} = (1 - c)W_{j0}$ .

Now consider an unexpected appreciation in domestic currency after Stage 1, and the exchange rate becomes  $e' < e$ . Since surplus funds are



in US dollars, after exchange rate shock it becomes  $W_{j1} = \frac{e'}{e} (1 - c) W_{j0}$  in domestic currency. Accordingly, prices of product  $Y$  and physical input  $K$  become  $e'P$  and  $e'(1 - c)$  respectively, while labor price  $w$  measured in domestic currency remains unchanged. Therefore firm  $j$ 's maximization problem at Stage 2 becomes<sup>1</sup>

$$\begin{aligned} V_{j2}(e') &= \max_{K_j, L_j, W_{j2} \geq 0} e' P A K_j^\alpha L_j^{1-\alpha} + W_{j2} \\ \text{s.t. } K_j &\leq e^{-1} \alpha W_{j0}, L_j \leq w^{-1} (1 - \alpha) W_{j0} \\ e' (1 - c) K_j &+ (1 - c) w L_j + W_{j2} = \frac{e'}{e} (1 - c) W_{j0} \end{aligned} \quad (\text{P3})$$

Let  $K_j^\dagger(e')$ ,  $L_j^\dagger(e')$ ,  $W_{j2}^\dagger(e')$ ,  $V_{j2}(e')$  denote the solution to the problem, then we have Proposition 2 as following:

PROPOSITION 2. *There exists constant value  $\bar{e} < e$  so that*

(a) *When  $\bar{e} < e' < e$ , the firm continues to exploit all physical capacity and fires skilled labors, and the firm value decreases, i.e.,  $K_j^\dagger(e') = S_j = e^{-1} \alpha W_{j0}$ ,  $L_j^\dagger(e') = \frac{e'}{e} H_j = \frac{e'}{e} w^{-1} (1 - \alpha) W_{j0}$ ,  $W_{j2}^\dagger(e') = 0$ ,  $V_{j2}(e') = e'^{2-\alpha} P A e^{-1} \alpha^\alpha \left(\frac{1-\alpha}{w}\right)^{1-\alpha} W_{j0}$*

(b) *When  $0 < e' < \bar{e}$ , the firm stops producing, leaving all physical capacity unused and all skilled workers unemployed, and the firm value equals its surplus fund, i.e.,  $K_j^\dagger(e') = 0$ ,  $L_j^\dagger(e') = 0$ ,  $W_{j2}^\dagger(e') = W_{j1}$ ,  $V_{j2}(e') = W_{j1}$ . where  $\bar{e} = \left(\frac{1-c}{P A \alpha^\alpha}\right)^{\frac{1}{1-\alpha}} \frac{W_0}{L_0}$ .*

It is observed from Proposition 2 that the firm value decreases when there is an unexpected appreciation in domestic currency. The impact of the exchange rate on the firm value can be divided into two effects: one is direct income effect—the appreciation of domestic value lowers the product price which in turn lowers sales revenue; since firms hold some foreign currency at their disposal, they also suffer a loss from devaluation of foreign currency. The other one is the substitution effect—since the domestic wage is measured in domestic currency, the relative price of skilled workers  $L$  to physical factor  $K$  increases as domestic currency appreciates, which motivates firms to substitute skilled workers with physical factor. However, physical investment cannot increase rapidly during a short time under the constraint of production capacity. Hence, firms will cut down on employment of skilled workers in order to take advantage of the change in

<sup>1</sup>Here we omit the first three variables in value function  $V_{j2}(S_j, H_j, W_{j1}, e)$ , which have been replaced by concrete values in the maximization problem.

relative price, which causes part of the loss. Particularly, when domestic currency appreciates dramatically, the firms stop producing and fire all skilled workers, and the entire industry breaks down.

### 3.3. Efficient Production Arrangement under Exchange Rate Shock

The social value created by firm  $j$  at Stage 2 can be divided into two parts: one is the total revenue of firm  $j$ , which equals firm value  $V_{j2}(e')$ ; the other is labor income, which is  $(1-c)wL_j$ . Hence, we have the following definition:

DEFINITION 3.1. The social value of firm  $j$  at Stage 2 is defined as  $SV_{j2} = e'PAK_j^\alpha L_j^{1-\alpha} + W_{j2} + (1-c)wL_j$ .

An efficient allocation is one which maximizes the firm's social value. From society's point of view, the firm is under two constraints during production: one is its capacity constraint; the other is the constraint of society's total surplus fund. Taking these into consideration, the society's optimal allocation of firm resources satisfies the following<sup>2</sup>

$$\begin{aligned} & \max_{K_j, L_j \geq 0} e'PAK_j^\alpha L_j^{1-\alpha} - e'(1-c)K_j + \frac{e'}{e}(1-c)W_{j0} \\ & s.t. K_j \leq e^{-1}\alpha W_{j0}, L_j \leq w^{-1}(1-\alpha)W_{j0} \\ & e'(1-c)K_j \leq \frac{e'}{e}(1-c)W_{j0} \end{aligned} \quad (P4)$$

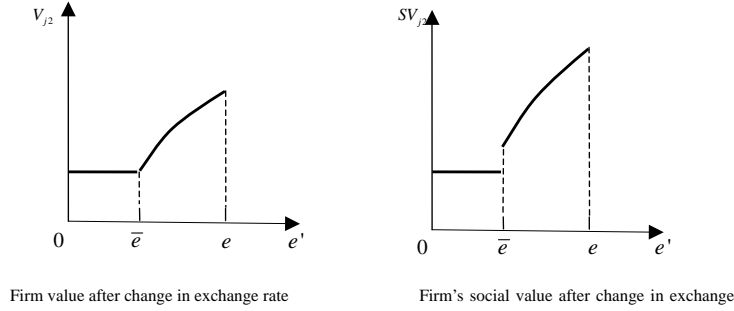
Solve the problem to get the socially optimal production arrangement and society's total income, which are denoted as  $K_j^o(e')$ ,  $L_j^o(e')$ . Then we have Proposition 3:

PROPOSITION 3. *At Stage 2, even under the capacity and fund constraints, the firm's efficient production arrangement is to produce according to the original production capacity regardless of changes in the exchange rate, i.e.,  $\forall e' > 0$ ,  $K_j^o(e') = S_j = e^{-1}\alpha W_{j0}$ ,  $L_j^o(e') = H_j = w^{-1}(1-\alpha)W_{j0}$ .*

We notice that since the labor market in the economy is closed, and human capital owned by skilled workers is firm-specific, labors cannot be employed by other firms after they are trained to become skilled workers by a particular firm. In other words, the social cost of skilled workers is zero, so that the socially efficient allocation is to use up all skilled workers to prevent waste in human capital.

<sup>2</sup>We have already simplified the problem.

FIG. 1.



### 3.4. Welfare Analysis under Exchange Rate Fluctuation

Based on the foregoing analysis, we will further demonstrate that since a certain number of skilled workers become unemployed when the exchange rate changes, the social cost of exchange rate shock is even higher than the private cost.

In order to observe changes in social welfare caused by exchange rate fluctuations, we substitute  $K_j^\dagger(e')$  and  $L_j^\dagger(e')$  into the social value function of firm  $j$ , and define  $SV(e') = SV_{j2}|_{K_j=K_j^\dagger(e'), L_j=L_j^\dagger(e')}$ , then we get the following propositions:

**PROPOSITION 4.** *When there is an unexpected and modest appreciation in domestic currency, the firm value decreases and labor unemployment increases which together lead to a larger extent of decrease in social welfare, i.e., when  $\bar{e} < e' < e$ ,  $\frac{\partial SV_{j2}(e')}{\partial e'} > \frac{\partial V_{j2}(e')}{\partial e'}$ .*

**PROPOSITION 5.** *When appreciation in exchange rate exceeds a certain benchmark so that firms stop producing, the firm's value function is continuous at the exchange rate  $\bar{e}$ , and the firm's social value jumps at the exchange rate  $\bar{e}$ , i.e., there exists  $c > 0$  so that  $\lim_{e' \rightarrow \bar{e}^+} SV(e') - SV(\bar{e}) > c > \lim_{e' \rightarrow \bar{e}^+} V_{j2}(e') - V_{j2}(\bar{e}) = 0$ .*

## 4. ECONOMIC POLICY UNDER APPRECIATION PRESSURE OF DOMESTIC CURRENCY

When an economy shifts from a fixed exchange rate regime to a flexible exchange rate regime, it is very likely for a domestic currency to appreciate rapidly after deregulation if it is undervalued by official exchange rate,

so that monetary authority would have to face the economic problems mentioned above. Economic entities and monetary authority can take the following measures to ease the appreciation pressure:

#### 4.1. Wage Cut

Since wages are usually measured in domestic currency in labor contracts, labor cost will increase dramatically after unexpected appreciation in domestic currency. The firm's loss will be reduced if wage can be adjusted through negotiation or labor policy, and employment will increase as well.

*PROPOSITION 6. When there is an unexpected appreciation in domestic currency in an economy under a fixed exchange rate regime, if wage can be adjusted according to changes in the exchange rate regime so that the new wage  $w' = \frac{e'}{e}w$  at Stage 2, the economy will not be affected by exchange rate shock.*

Hence, rigid wage is among the causes of increases in unemployment and decreases in firm value. In reality, when changes in the exchange rate cause labor cost to increase relatively, employers usually renegotiate with workers to adjust the wage level. However, wage adjustment through negotiation is very limited, and it is far from solving the problem when the exchange rate changes dramatically.

#### 4.2. Announce Reform of Exchange Rate Regime in Advance

According to equilibrium analysis under a fixed exchange rate regime, firms are able to accurately predict the exchange rate when it is fixed, and they will make their production decisions according to the expectation. There will be no waste of resources since the firm behavior is consistent with the expectation, which will coincide with the reality later. As a result, an expected change in exchange rate will not have a great impact on the economy and firms, since firms will take the changes into consideration when signing contracts and establishing production capacity. In our model, if the monetary authority announces the schedule of exchange rate reform at Stage 0, firms will be able to predict future exchange rate  $e_1$  and  $e_2$ .

*PROPOSITION 7. When the exchange rate changes, firms are able to match input factors with production capacity at equilibrium as long as they can accurately predict future exchange rate  $e_1, e_2$  at Stage 0, i.e.,  $\forall j, S_j = K_j, H_j = L_j$ .*

In reality, those countries in control of domestic currency while facing appreciation pressure usually prescribe in advance the mode and path of

appreciation in order to reduce shock caused by irregular exchange rate fluctuation. In many countries which achieved gradual reform of the exchange rate, governments employ an exchange rate reform schedule to deliver policy information and change public expectation. It has proved to be very effective if the government has enough accountability.

### 4.3. Partial Deregulation of the Exchange Rate

When the schedule of exchange rate reform is not applicable, such as when there is not enough time to build up expectation or the government lacks accountability, the government could adopt other measures to react to domestic currency appreciation.

For instance, if the economy has reached Stage 2 in our model, the reform schedule will not be applicable. However, the cost of appreciation in domestic currency will be controlled if the government poses certain restrictions on the range of fluctuation in domestic currency. When domestic currency is significantly undervalued ( $0 < e' < \bar{e}$ ), the economy is likely to suffer from serious depression under complete exchange rate deregulation. The government could adopt temporary measures such as pegging and controlled fluctuation, and then gradually widen the range of fluctuation in order to prevent depression.

Additionally, the economy could react to rapid changes in the exchange rate through trade policy and transferring industries abroad.

## 5. CONCLUSION

This paper establishes a three-stage production model under the constraint of production capacity to study the reaction of an economy under a fixed exchange rate regime to an unexpected appreciation in domestic currency. In the model, appreciation in domestic currency changes the relative price of a firm's output to input, which motivates firms to make adjustments in production allocation by cutting down on the relatively expensive skilled labor. Decreases in output and product price shrink the firm's value. At the same time, the waste of human capital caused by the production adjustment increases the social cost of appreciation in domestic currency. Particularly, when the exchange rate appreciates rapidly within a short time, tradable industries in the economy are likely to suffer from depression or even breakdown.

In the end, it needs to be pointed out that our conclusions are drawn under certain conditions and simplification. Further discussion is still needed. For instance, we assume that human capital is firm-specific, whereas in reality, even skilled workers can transfer between firms at some cost. Therefore the production capacity in firm competition assumes a more complicated form. Another problem is that we assume that the fluctuation in the ex-

change rate is exogenous and unexpected, while economic entities could partly anticipate the fluctuation and form their own belief about future changes in the exchange rate, which will affect firm behaviors. Finally, the equilibrium in our model is only partial since there are both tradable and non-tradable sections in a real economy. Therefore the study needs to expand to include different impacts of an exchange rate shock on different sectors. Optimal reform policy of exchange rate regime depends on the synthetic impact of exchange rate shock on all sectors in the economy, and needs to be balanced among the cost and profit of different sectors.

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