Can a reduction in credit card processing fees offset the effect of a hike in the minimum wage?

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The objective of this study is to assess whether a reduction in credit card processing fees can offset the effect of a hike in the minimum wage by examining the unique case of South Korea. To do so, this study introduces a theoretical model with money and credit as the explicit means of payment. In particular, it develops a general equilibrium model with micro-foundations for dealing with the relationship between minimum wage increases and job automation, and takes a long-run approach in the quantitative analysis. Contrary to the existing literature, the study shows that a minimum wage hike negatively and significantly affects overall employment. The calibrated results show that a 13.6% hike in the minimum wage causes a 16.46% reduction in the demand for simple labor earning the minimum wage, and also decreases the demand for non-simple labor by 0.157%. In contrast, if a policy of reducing credit card processing fees is adopted to ease the negative effect of a hike in minimum wage on employment, a 0.65% reduction in these fees (derived by shifting the burden of interest on credit card debt from seller to buyer) results in a 0.09% decrease in the labor demand.

JEL classification: J38; E42; J23

Keywords: Hike in minimum wage; Reduction in credit card processing fee; Job automation

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1. Introduction

From 2017 to 2018, South Korea increased its minimum hourly wage by 16.4%. This represents a large jump given that the increases from 2011 to 2017 were only 5 to 7% per annum. Furthermore, the 2019 increase was 10.9%.

This rapid increase in the minimum wage has triggered severe opposition from small businesses. According to a Statistics Korea Economic Census, the proportion of establishments with one to nine workers was 92% in 2015. In response to the complaints by a significant number of employers about the minimum wage increase, the South Korean government has reduced the ceiling on credit card processing fees from 2.3% to 1.4% or 1.6%.

Credit card companies have two main options in the face of this reduction. They can either reduce the supplementary services they offer to customers or shift the charge for funding costs from seller to buyer.[1] Traditionally, credit card companies raise the funds to pre-pay the price of purchased goods and services to the seller instead of the buyer. They pass most of the funding costs to the seller in the form of credit card processing fees, and the buyer bears only a small part of the funding costs in the form of an annual credit card membership fee. In this system, the buyer pays some of the funding costs,

[1] Funding costs are equal to the interest costs for credit card debt, given that there is no medium margin between the buyers and the credit card companies.

but the seller pays most of the costs to expedite the buyer's consumption. Thus, most sellers strongly advocate reducing their credit card processing fees by switching the burden of funding costs to buyers through annual credit card membership fees.

Credit companies find themselves unable to take the first option of reducing their supplementary services, as this is prohibited for at least three years by the *Specialized Credit Financial Business Act*. Furthermore, the Financial Supervisory Service seldom permits this even after the prohibited period. Thus, this study focuses on the second option of shifting the funding costs from seller to buyer.[2]

South Korea is a unique case, in that the nation is simultaneously experiencing both significant hikes in the minimum wage and a major reduction in credit card processing fees. Without serious consideration of the effects of both events, the South Korean government has introduced the policy of reducing credit card processing fees to ease the negative effect on employment derived from the higher labor costs from the minimum wage hike. Thus, the objective of this study is to examine the unique case of South Korea to assess whether a reduction in credit card processing fees can offset the effect of a hike in the minimum wage.

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[2] As the Bank of Korea raised the benchmark interest rate from 1.5% to 1.75% in November 2018, it is more likely that credit card companies will switch the charge for funding costs from sellers to buyers.

To do this analysis, this study extends the model developed by Aruoba et al. (2011) by first inserting the concepts of a minimum wage and job automation, and then including a proposal concerned with credit card processing fees.

At present, there is no consensus on the effect on employment of a minimum wage hike. Although neoclassical economic theories suggest that increasing the minimum wage negatively affects employment, many studies (e.g., Card, 1992; Card and Krueger, 1994; Zavodny, 2000; Dube et al., 2010; Giuliano, 2013) have found a very small effect on employment or none at all. However, these studies have not considered the relationship between minimum wage increases and job automation. Recently, job automation has accelerated along with the rapid development of information and communication technology (ICT). A study by Aaronson and Phelan (2017) found that minimum wage hikes decrease cognitively routine jobs but do not significantly affect overall employment. However, their study applied the partial equilibrium theory and the empirical analysis considered only the short run. Lordan and Neumark (2017) showed that increasing the minimum wage significantly decreases the share of automatable employment held by low-skilled workers, most notably older workers, although their findings suggest that the net dis-employment effect of the minimum wage hike is not significant. Again, their analysis was based on a short-run empirical estimation and thus lacked micro-foundations.

To examine the macroeconomic effects of a reduction in credit card processing fees, it is vital to use a model environment featuring the kinds of friction that make a medium of exchange essential. Aruoba et al. (2011) explicitly dealt with the roles of money and credit as means of payment, based on a model proposed by Lagos and Wright (2005). However, their main focus was the effects of anticipated inflation on capital formation.

This study extends the literature in several ways. First, it develops a general equilibrium model with micro-foundations to examine the relationship between minimum wage increases and job automation, and takes a long-run approach to quantitative analysis. This model indicates that hikes in the minimum wage negatively and significantly affect overall employment, contrary to the existing literature. Second, this study analyzes the macroeconomic effects of both a minimum wage hike and a reduction in credit card processing fees using a model with the explicit use of money and credit as the means of payment.

The remainder of this study is organized as follows. Section 2 establishes a model that serves as the theoretical framework for the study. Section 3 provides the calibration strategy and the quantitative results. Section 4 presents the study's conclusions.

2. The model

2.1. General assumptions

Economic activity takes place in two main sectors, namely competitive markets (CMs) and, to a lesser degree, decentralized markets (DMs). In CMs there are no frictions, but in DMs a double-coincidence problem and anonymity both exist. For bartering, each person in a pairwise meeting should want what the other person has. If any one of them does not want what the other person has, trade does not occur. In the DM, a double-coincidence problem can occur. Furthermore, an anonymity problem can occur, because there is no information about a trading partner. These two kinds of friction make money essential as a medium of exchange. In cases where a technology is available to keep track of credit information regarding a trading partner, credit cards can serve as a medium of exchange for trading. In the CM, there is no double-coincidence problem, and all of the information about the trading partners is open to the public. Thus, money is not necessary for trading.

In the CM, general goods are traded. As these general goods are homogeneous, only repetitive simple labor is necessary to produce them. This kind of simple labor can be replaced by automation, or computer capital. In the DM, goods can be traded through money or through credit cards. As production of heterogeneous DM goods does not involve repetitive simple labor, computer capital is not applicable.

The utility function of a household in the CM is determined as follows:

$$u(c_t,\, h_t^s) = \ln c_t - A h_t^s \tag{1}$$

where c_t is the consumption of general goods in time *t*, and h_t^s is the labor supply. Note that the utility function is linear in h_t^s. This linearity significantly reduces the complexity of the analysis.

The production function is as follows:

$$y_t = h_{ns,t}^{\gamma}\left[\lambda h_{s,t}^{\rho} + (1-\lambda)k_{c,t}^{\rho}\right]^{\frac{\chi}{\rho}} k_{nc,t}^{1-\gamma-\chi} \tag{2}$$

where y_t, $h_{ns,t}$, $h_{s,t}$, $k_{c,t}$, and $k_{nc,t}$ denote the production of general goods, non-simple labor demand, simple labor demand, computer capital demand, and non-computer capital demand, respectively. In addition, the elasticity between simple labor demand and computer capital is shown by $\varphi = 1/(1-\rho) > 1$ and $\gamma,\, \lambda,\, \chi \in (0,\, 1)$. Note that $\varphi > 1$ reflects the concept of job automation, as explained by Autor and Dorn (2013).

General goods are produced through combining two types of functions. The first type is a constant elasticity of substitution (CES) function, which is formed by combining simple labor demand and computer capital demand. The CES function adequately explains the substitution relationship between these demands. As simple labor is mostly repetitive, it can be replaced by computer capital. The second type of function is a Cobb-Douglas function, which is formed by combining the non-simple labor demand, the total simple labor demand (i.e., the CES function formed by simple labor demand and computer capital demand), and the non-computer capital demand. Non-simple labor is relatively difficult to replace with computer capital, and non-computer capital is relatively complementary to labor, as shown by Eden and Gaggl (2014). The Cobb-Douglas function effectively shows this relationship among the various kinds of demand.

In the DM, buyers get utility by consuming DM goods. Thus, their utility function is as follows:

$$u(q_t) = \ln(q_t + b) - \ln b \tag{3}$$

where q_t is the goods traded through money, and b is a technical parameter for meeting the condition $u(0)=0$. In contrast, sellers get disutility by producing DM goods. Thus, their disutility function is as follows:

$$c(q_t,\, k^s_{nc,t}) = q_t^{\psi}\,(k^s_{nc,t})^{1-\psi} \tag{4}$$

where $k^s_{nc,t}$ is the non-computer capital that sellers have, and $\psi > 1$. Note that computer capital is not used in the DM, as explained above.

Both buyers and sellers have non-computer capital in the DM. However, they cannot use it as a means of payment, because it is not portable and it is fixed at their respective locations. In addition, as buyers cannot produce DM goods, only sellers can use non-computer capital as a production factor.

2.2. Household's problem

In the CM, the utility maximization problem of a household is

$$W_t(m_t,\, k^s_{nc,t},\, k^s_{c,t},\, \ell_t) = \max_{c_t,\, h^s_t,\, m_{t+1},\, k^s_{nc,t+1},\, k^s_{c,t+1}} \left\{ \ln c_t - Ah^s_t + \beta V_{t+1}(m_{t+1},\, k^s_{nc,t+1},\, k^s_{c,t+1}) \right\} \tag{5}$$

subject to

$$\begin{aligned} & p_t c_t + m_{t+1} + (1+\varepsilon)\ell_t + p_t i_{nc,t} + p_t i_{c,t} \\ & = p_t w_{ns,t}\alpha h^s_t + p_t \underline{w}(1-\alpha)h^s_t + p_t r_{nc,t} k^s_{nc,t} + p_t r_{c,t} k^s_{c,t} + m_t + \tau M^s_t \end{aligned} \tag{6}$$

where $W_t(m_t, k^s_{nc,t}, k^s_{c,t}, \ell_t)$ is the value function of a household in the CM that is holding amounts of money m_t, non-computer capital $k^s_{nc,t}$, computer capital $k^s_{c,t}$, and is owing credit card debt ℓ_t from the previous DM. In addition, $V_{t+1}(m_{t+1}, k^s_{nc,t+1}, k^s_{c,t+1})$ is the value function in the DM. p_t, $i_{nc,t}$, $i_{c,t}$, $w_{ns,t}$, $\underline{w}$, $r_{nc,t}$, $r_{c,t}$, and M^s_t denote the prices for general goods (denominated in dollars), the investment in non-computer capital, the investment in computer capital, the wages for non-simple labor, the wages for simple labor (i.e., minimum wages), the price for non-computer capital, the price for computer capital, and the money supply, respectively.[3] Concerning the specific forms of these investments, $i_{nc,t} = k^s_{nc,t+1} - (1-\delta_{nc})k^s_{nc,t}$ and $i_{c,t} = k^s_{c,t+1} - (1-\delta_c)k^s_{c,t}$, where δ_{nc} and δ_c are the depreciation rates for non-computer capital and computer capital, respectively. Concerning the parameters, β, ε, $\alpha \in (0, 1)$, and τ are the discount factor, the interest rate for credit card debt, the share of non-simple labor, and the growth rate of the money supply, respectively.

As there is no rate of return on money holdings, this model is non-stationary. Dividing both sides of Equation (6) by M^s_t eases this non-stationarity. For further analysis, the symbol "∧" is added to a nominal variable in the case where it is divided by M^s_t (e.g.,

[3] This study considers the wage for simple labor as the minimum wage. According to a survey on work status by employment type that was conducted by the Ministry of Employment and Labor in 2016, the average monthly regular salary of simple laborers is 1,526 thousand won (the currency of South Korea), and this salary is the lowest among all the types of laborers. Thus, the wage for simple labor can be considered as the minimum wage, given that a regular salary is more inclusive than the minimum wage.

$\hat{p}_t = p_t / M_t^s$). Then, Equation (6) can be changed as follows:

$$c_t + \frac{\hat{m}_{t+1}(1+\tau)}{\hat{p}_t} + \frac{(1+\varepsilon)\hat{\ell}_t}{\hat{p}_t} + i_{nc,t} + i_{c,t} = w_{ns,t}\alpha h_t^s + \underline{w}(1-\alpha)h_t^s + r_{nc,t}k_{nc,t}^s + r_{c,t}k_{c,t}^s + \frac{\hat{m}_t}{\hat{p}_t} + \frac{\tau}{\hat{p}_t} \tag{7}$$

In eliminating h_t^s by using Equation (7), Equation (5) is substituted by

$$\begin{aligned} W_t(\hat{m}_t, k_{nc,t}^s, k_{c,t}^s, \hat{\ell}_t) &= \frac{A\hat{m}_t}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t} - \frac{A(1+\varepsilon)\hat{\ell}_t}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t} \\ &+ \frac{A\tau}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t} + \frac{A(1-\delta_{nc}+r_{nc,t})k_{nc,t}^s}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]} + \frac{A(1-\delta_c+r_{c,t})k_{c,t}^s}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]} \\ &+ \max_{c_t,\, \hat{m}_{t+1},\, k_{nc,t+1}^s,\, k_{c,t+1}^s} \left\{ \begin{array}{l} \ln c_t - \frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]}\left[c_t + \frac{\hat{m}_{t+1}(1+\tau)}{\hat{p}_t} + k_{nc,t+1}^s + k_{c,t+1}^s\right] \\ +\beta V_{t+1}(\hat{m}_{t+1}, k_{nc,t+1}^s, k_{c,t+1}^s) \end{array} \right\} \end{aligned} \tag{8}$$

Note that $\hat{m}_t$, $k_{nc,t}^s$, $k_{c,t}^s$, and $\hat{\ell}_t$ do not affect the determination of $\hat{m}_{t+1}$, $k_{nc,t+1}^s$, and $k_{c,t+1}^s$ for the next period. The first-order conditions in terms of c_t, $\hat{m}_{t+1}$, $k_{nc,t+1}^s$, and $k_{c,t+1}^s$ are

$$\frac{1}{c_t} = \frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]} \tag{9}$$

$$\frac{A(1+\tau)}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t} = \beta V_{t+1,\hat{m}}(\hat{m}_{t+1}, k_{nc,t+1}^s, k_{c,t+1}^s) \tag{10}$$

$$\frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]} = \beta V_{t+1,k_{nc}^s}(\hat{m}_{t+1}, k_{nc,t+1}^s, k_{c,t+1}^s) \tag{11}$$

$$\frac{A}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]}=\beta V_{t+1,\,k_c^s}(\hat{m}_{t+1},\,k_{nc,t+1}^s,\,k_{c,t+1}^s) \tag{12}$$

It is obvious from Equation (8) that $W_t(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s,\,\hat{\ell}_t)$ is linear in terms of $\hat{m}_t$, $k_{nc,t}^s$, $k_{c,t}^s$, and $\hat{\ell}_t$. Thus, the partial derivatives of these variables are as follows:

$$W_{t,\,\hat{m}}(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s,\,\hat{\ell}_t)=\frac{A}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t} \tag{13}$$

$$W_{t,\,k_{nc}^s}(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s,\,\hat{\ell}_t)=\frac{A(1-\delta_{nc}+r_{nc,t})}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]} \tag{14}$$

$$W_{t,\,k_c^s}(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s,\,\hat{\ell}_t)=\frac{A(1-\delta_c+r_{c,t})}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]} \tag{15}$$

$$W_{t,\,\hat{\ell}}(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s,\,\hat{\ell}_t)=-\frac{A(1+\varepsilon)}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t} \tag{16}$$

The value function in the DM is given by

$$\begin{aligned}V_t(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s)&=\sigma V_t^b(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s)+\sigma V_t^s(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s)\\&+(1-2\sigma)W_t(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s,\,0)\end{aligned} \tag{17}$$

where $V_t^b(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s)$ and $V_t^s(\hat{m}_t,\,k_{nc,t}^s,\,k_{c,t}^s)$ are the value functions of the buyers and sellers, respectively. In addition, σ is the probability of being a buyer or a seller. A buyer wants to consume, but cannot produce. A seller can produce, but not consume. The first and second terms in the right side of Equation (17) are the values of being a buyer or a seller. The last term is the value for no trade.

The value functions of the buyers and sellers are given by

$$\begin{aligned} V_t^b(\hat{m}_t, k_{nc,t}^s, k_{c,t}^s) &= \omega\left[\ln(q_t^b + b) - \ln b + W_t(\hat{m}_t - \hat{d}_t^b, k_{nc,t}^s, k_{c,t}^s, 0)\right] \\ &+(1-\omega)\left[\ln(\tilde{q}_t^b + b) - \ln b + W_t(\hat{m}_t, k_{nc,t}^s, k_{c,t}^s, \frac{(1+\nu\varepsilon)\hat{\ell}_t^b}{1+\varepsilon})\right] \end{aligned} \tag{18}$$

$$\begin{aligned} V_t^s(\hat{m}_t, k_{nc,t}^s, k_{c,t}^s) &= \omega\left[-(q_t^s)^{\psi}(k_{nc,t}^s)^{1-\psi} + W_t(\hat{m}_t + \hat{d}_t^s, k_{nc,t}^s, k_{c,t}^s, 0)\right] \\ &+(1-\omega)\left[-(\tilde{q}_t^s)^{\psi}(k_{nc,t}^s)^{1-\psi} + W_t(\hat{m}_t, k_{nc,t}^s, k_{c,t}^s, -\hat{\ell}_t^s + \zeta)\right] \end{aligned} \tag{19}$$

where $q_t^b(q_t^s)$ is the quantity of goods exchanged when buying (selling) for money, and $\hat{d}_t^b(\hat{d}_t^s)$ is the money paid (received) for the goods. In addition, $\tilde{q}_t^b(\tilde{q}_t^s)$ is the quantity of goods exchanged when buying (selling) with a credit card, and $\hat{\ell}_t^b(\hat{\ell}_t^s)$ is the debt paid (received) for the goods by using a credit card. $\omega \equiv \hat{d}^* / (\hat{d}^* + \hat{\ell}^*)$ is the probability that money plays a role as the means of payment, and $1-\omega$ is the probability that a credit card is the means of payment.[4] The credit card processing fee is $\zeta = \left[\eta + (1-\nu)\varepsilon\hat{\ell}_t^s\right] / (1+\varepsilon)$, where $(1-\nu)\varepsilon\hat{\ell}_t^s$ denotes the funding costs, and η represents the sum of the other costs. For the interest costs on credit card debt, $\varepsilon\hat{\ell}_t$, the buyers bear $\nu\varepsilon\hat{\ell}_t$ and the sellers bear $(1-\nu)\varepsilon\hat{\ell}_t$, where $\nu \in [0, 1]$.[5]

After inserting Equations (18) and (19) into Equation (17), the partial derivatives in

[4] $\hat{d}^*$ and $\hat{\ell}^*$ denote steady states of $\hat{d}_t$ and $\hat{\ell}_t$, respectively, which vary as a policy changes.

[5] Sellers bear most of the interest costs for credit card debt, as a means to boost consumption by the buyers, although it is rational for buyers to bear those costs.

terms of $\hat{m}_t$, $k^s_{nc,t}$, and $k^s_{c,t}$ are

$$
\begin{aligned}
V_{t,\hat{m}}(\hat{m}_t, k^s_{nc,t}, k^s_{c,t}) &= \frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t} \\
&+\sigma\omega\left\{\frac{1}{q^b_t + b}\frac{\partial q^b_t}{\partial \hat{m}_t} - \frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial \hat{d}^b_t}{\partial \hat{m}_t}\right\} \\
&+\sigma\omega\left\{-\psi(q^s_t)^{\psi-1}(k^s_{nc,t})^{1-\psi}\frac{\partial q^s_t}{\partial \hat{m}_t} + \frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial \hat{d}^s_t}{\partial \hat{m}_t}\right\}
\end{aligned}
\tag{20}
$$

$$
\begin{aligned}
V_{t,k^s_{nc}}(\hat{m}_t, k^s_{nc,t}, k^s_{c,t}) &= \frac{A(1-\delta_{nc}+r_{nc,t})}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]} \\
&+\sigma\omega\left\{\frac{1}{q^b_t + b}\frac{\partial q^b_t}{\partial k^s_{nc,t}} - \frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial \hat{d}^b_t}{\partial k^s_{nc,t}}\right\} \\
&+\sigma(1-\omega)\left\{\frac{1}{\tilde{q}^b_t + b}\frac{\partial \tilde{q}^b_t}{\partial k^s_{nc,t}} - \frac{A(1+\nu\varepsilon)}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial \hat{\ell}^b_t}{\partial k^s_{nc,t}}\right\} \\
&+\sigma\omega\left\{\begin{aligned}&-\psi(q^s_t)^{\psi-1}(k^s_{nc,t})^{1-\psi}\frac{\partial q^s_t}{\partial k^s_{nc,t}} - (q^s_t)^{\psi}(1-\psi)(k^s_{nc,t})^{-\psi} \\ &+\frac{A}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial \hat{d}^s_t}{\partial k^s_{nc,t}}\end{aligned}\right\} \\
&+\sigma(1-\omega)\left\{\begin{aligned}&-\psi(\tilde{q}^s_t)^{\psi-1}(k^s_{nc,t})^{1-\psi}\frac{\partial \tilde{q}^s_t}{\partial k^s_{nc,t}} - (\tilde{q}^s_t)^{\psi}(1-\psi)(k^s_{nc,t})^{-\psi} \\ &+\frac{A(1+\nu\varepsilon)}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial \hat{\ell}^s_t}{\partial k^s_{nc,t}}\end{aligned}\right\}
\end{aligned}
\tag{21}
$$

$$
V_{t,k^s_c}(\hat{m}_t, k^s_{nc,t}, k^s_{c,t}) = \frac{A(1-\delta_c+r_{c,t})}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha)\right]}
\tag{22}
$$

This study adopts the generalized Nash bargaining protocol to determine the terms of trade (q_t , $\tilde{q}_t$, $\hat{d}_t$, and $\hat{\ell}_t$) in the DM.

First, consider the case in which only money is available as a means of payment.

The buyers and sellers face the problem of determining q_t and $\hat{d}_t$ for maximizing Equation (23), subject to Equation (24).

$$\max_{q_t,\,\hat{d}_t}\left\{\begin{array}{l}\left[\ln(q_t+b)-\ln b+W_t(\hat{m}_t-\hat{d}_t,\,k^s_{nc,t},\,k^s_{c,t},\,0)\right]^{\theta}\\ \left[-q_t^{\psi}(k^s_{nc,t})^{1-\psi}+W_t(\hat{m}_t+\hat{d}_t,\,k^s_{nc,t},\,k^s_{c,t},\,0)\right]^{1-\theta}\end{array}\right\} \tag{23}$$

$$\hat{d}_t\le\hat{m}_t \tag{24}$$

where $\theta\in(0,\,1)$ denotes the bargaining power of a buyer. As money holdings cause opportunity costs such as bank deposit rates, in equilibrium, $\hat{d}_t=\hat{m}_t$. Thus, Equation (23) can be rearranged to

$$\max_{q_t}\left\{\begin{array}{l}\left[\ln(q_t+b)-\ln b-\dfrac{A\hat{m}_t}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t}\right]^{\theta}\\ \left[-q_t^{\psi}(k^s_{nc,t})^{1-\psi}+\dfrac{A\hat{m}_t}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t}\right]^{1-\theta}\end{array}\right\} \tag{25}$$

The first-order condition in terms of q_t is

$$\frac{\hat{m}_t}{\hat{p}_t}=\frac{f(q_t,\,k^s_{nc,t})\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]}{A} \tag{26}$$

where

$$f(q_t, k^s_{nc,t}) = \frac{\theta(\frac{1}{q_t + b}) q_t^{\psi} (k^s_{nc,t})^{1-\psi} + (1-\theta)\psi q_t^{\psi-1} (k^s_{nc,t})^{1-\psi} \left[\ln(q_t + b) - \ln b\right]}{\theta(\frac{1}{q_t + b}) + (1-\theta)\psi q_t^{\psi-1} (k^s_{nc,t})^{1-\psi}} \tag{27}$$

Second, consider the case in which only credit cards are available as the means of payment. The buyers and sellers face the problem of determining $\tilde{q}_t$ and $\hat{\ell}_t$ for maximizing Equation (28).

$$\max_{\tilde{q}_t, \hat{\ell}_t} \left\{ \begin{array}{l} \left[\ln(\tilde{q}_t + b) - \ln b + W_t(\hat{m}_t, k^s_{nc,t}, k^s_{c,t}, \frac{(1+\nu\varepsilon)\hat{\ell}_t}{1+\varepsilon}) \right]^{\theta} \\ \left[-\tilde{q}_t^{\psi} (k^s_{nc,t})^{1-\psi} + W_t(\hat{m}_t, k^s_{nc,t}, k^s_{c,t}, -\hat{\ell}_t + \zeta) \right]^{1-\theta} \end{array} \right\} \tag{28}$$

Equation (28) can be rearranged through Equation (8) as follows:

$$\max_{\tilde{q}_t, \hat{\ell}_t} \left\{ \begin{array}{l} \left[\ln(\tilde{q}_t + b) - \ln b - \frac{A(1+\nu\varepsilon)\hat{\ell}_t}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha) \right] \hat{p}_t}) \right]^{\theta} \\ \left[-\tilde{q}_t^{\psi} (k^s_{nc,t})^{1-\psi} + \frac{A(1+\varepsilon)\hat{\ell}_t}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha) \right] \hat{p}_t} - \frac{A\left[\eta + (1-\nu)\varepsilon\hat{\ell}_t \right]}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha) \right] \hat{p}_t} \right]^{1-\theta} \end{array} \right\} \tag{29}$$

The first-order conditions, in terms of $\tilde{q}_t$ and $\hat{\ell}_t$, are

$$\frac{A(1+\nu\varepsilon)\hat{\ell}_t}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha) \right] \hat{p}_t} = \frac{\theta(\frac{1}{\tilde{q}_t + b}) \tilde{q}_t^{\psi} (k^s_{nc,t})^{1-\psi} + (1-\theta)\psi \tilde{q}_t^{\psi-1} (k^s_{nc,t})^{1-\psi} \left[\ln(\tilde{q}_t + b) - \ln b\right] + \theta(\frac{1}{\tilde{q}_t + b}) \frac{A\eta}{\left[w_{ns,t}\alpha + \underline{w}(1-\alpha) \right] \hat{p}_t}}{\theta(\frac{1}{\tilde{q}_t + b}) + (1-\theta)\psi \tilde{q}_t^{\psi-1} (k^s_{nc,t})^{1-\psi}} \tag{30}$$

$$\frac{A(1+\nu\varepsilon)\hat{\ell}_t}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t}$$
$$=(1-\theta)\left[\ln(\tilde{q}_t+b)-\ln b\right]+\theta\tilde{q}_t^{\psi}(k_{nc,t}^{s})^{1-\psi}+\frac{\theta A\eta}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t} \tag{31}$$

Equations (30) and (31) imply that $u'(\tilde{q}_t)=c_{\tilde{q}}(\tilde{q}_t,\, k_{nc,t}^{s})$.

The relevant derivatives in Equation (20) are $\partial\hat{d}_t^{b}/\partial\hat{m}_t=1$, $\partial\hat{d}_t^{s}/\partial\hat{m}_t=0$, and $\partial q_t^{s}/\partial\hat{m}_t=0$. In addition, $\partial q_t^{b}/\partial\hat{m}_t=A/\left\{\left[w_{nr,t}\alpha+w_{r,t}(1-\alpha)\right]f_q\hat{p}_t\right\}$ (from Equation (26)). Inserting these derivatives into Equation (20) gives

$$V_{t,\hat{m}}(\hat{m}_t,\, k_{nc,t}^{s},\, k_{c,t}^{s})=\frac{(1-\sigma\omega)A}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t}+\frac{\sigma\omega A}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t f_q(q_t^{b}+b)} \tag{32}$$

The relevant derivatives in Equation (21) are $\partial q_t^{b}/\partial k_{nc,t}^{s}=0$, $\partial\hat{d}_t^{b}/\partial k_{nc,t}^{s}=0$, $\partial\tilde{q}_t^{b}/\partial k_{nc,t}^{s}=0$, $\partial\hat{\ell}_t^{b}/\partial k_{nc,t}^{s}=0$, and $\partial\hat{d}_t^{s}/\partial k_{nc,t}^{s}=0$. Furthermore, $\partial q_t^{s}/\partial k_{nc,t}^{s}=-(f_{k_{nc}^{s}}/f_q)$ (from Equation (26)), where

$$f_{k_{nc}^{s}}=\frac{\theta(\frac{1}{q_t+b})q_t^{\psi}(1-\psi)(k_{nc,t}^{s})^{-\psi}\left[\theta(\frac{1}{q_t+b})+(1-\theta)\psi q_t^{\psi-1}(k_{nc,t}^{s})^{1-\psi}\right]}{\left[\theta(\frac{1}{q_t+b})+(1-\theta)\psi q_t^{\psi-1}(k_{nc,t}^{s})^{1-\psi}\right]^2}$$
$$+\frac{\theta(1-\theta)\left[\ln(q_t+b)-\ln b-q_t^{\psi}(k_{nc,t}^{s})^{1-\psi}\right]\left[(\frac{1}{q_t+b})\psi q_t^{\psi-1}(1-\psi)(k_{nc,t}^{s})^{-\psi}\right]}{\left[\theta(\frac{1}{q_t+b})+(1-\theta)\psi q_t^{\psi-1}(k_{nc,t}^{s})^{1-\psi}\right]^2} \tag{33}$$

$$f_q = \frac{(\frac{1}{q_t+b})\psi q_t^{\psi-1}(k_{nc,t}^s)^{1-\psi}\left[\theta(\frac{1}{q_t+b})+(1-\theta)\psi q_t^{\psi-1}(k_{nc,t}^s)^{1-\psi}\right]}{\left[\theta(\frac{1}{q_t+b})+(1-\theta)\psi q_t^{\psi-1}(k_{nc,t}^s)^{1-\psi}\right]^2}$$
$$+\frac{\theta(1-\theta)\left[\ln(q_t+b)-\ln b-q_t^{\psi}(k_{nc,t}^s)^{1-\psi}\right]\left[(\frac{1}{q_t+b})\psi(\psi-1)q_t^{\psi-2}(k_{nc,t}^s)^{1-\psi}+\psi q_t^{\psi-1}(k_{nc,t}^s)^{1-\psi}(\frac{1}{q_t+b})^2\right]}{\left[\theta(\frac{1}{q_t+b})+(1-\theta)\psi q_t^{\psi-1}(k_{nc,t}^s)^{1-\psi}\right]^2} \quad (34)$$

The partial derivative of Equation (31) with respect to $k_{nc,t}^s$ is

$$\frac{A(1+\nu\varepsilon)}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]\hat{p}_t}\frac{\partial\hat{\ell}_t}{\partial k_{nc,t}^s}$$
$$=\psi\tilde{q}_t^{\psi-1}(k_{nc,t}^s)^{1-\psi}\frac{\partial\tilde{q}_t}{\partial k_{nc,t}^s}+\theta\tilde{q}_t^{\psi}(1-\psi)(k_{nc,t}^s)^{-\psi} \quad (35)$$

Inserting these derivatives into Equation (21) leads to

$$V_{t,k_{nc}^s}(\hat{m}_t, k_{nc,t}^s, k_{c,t}^s)=\frac{A(1-\delta_{nc}+r_{nc,t})}{\left[w_{ns,t}\alpha+\underline{w}(1-\alpha)\right]}$$
$$+\sigma\omega\left\{\psi(q_t^s)^{\psi-1}(k_{nc,t}^s)^{1-\psi}(\frac{f_{k_{nc}^s}}{f_q})-(q_t^s)^{\psi}(1-\psi)(k_{nc,t}^s)^{-\psi}\right\} \quad (36)$$
$$-\sigma(1-\omega)(1-\theta)(\tilde{q}_t^s)^{\psi}(1-\psi)(k_{nc,t}^s)^{-\psi}$$

Based on the specified value functions in the DM, the optimal conditions derived from the utility maximization problem can be rearranged. Inserting Equations (9) and (32) into Equation (10) gives

$$\frac{1+\tau}{c_t \hat{p}_t} = \frac{\beta}{c_{t+1}\hat{p}_{t+1}} \left\{ (1-\sigma\omega) + (\sigma\omega) \frac{1}{f_q(q_{t+1},\, k^s_{nc,t+1})(q_{t+1}+b)} \right\} \tag{37}$$

Equation (11) can be changed by using Equations (9) and (36), as follows:

$$\frac{1}{c_t} = \beta \left\{ \begin{array}{l} \dfrac{1}{c_{t+1}}(1-\delta_{nc}+r_{nc,t+1}) \\ +\sigma\omega\left[\psi(q^s_{t+1})^{\psi-1}(k^s_{nc,t+1})^{1-\psi} \dfrac{f_{k^s_{nc}}(q^s_{t+1},\, k^s_{nc,t+1})}{f_q(q^s_{t+1},\, k^s_{nc,t+1})} - (q^s_{t+1})^{\psi}(1-\psi)(k^s_{nc,t+1})^{-\psi} \right] \\ -\sigma(1-\omega)(1-\theta)(\tilde{q}^s_{t+1})^{\psi}(1-\psi)(k^s_{nc,t+1})^{-\psi} \end{array} \right\} \tag{38}$$

Inserting Equations (9) and (22) into Equation (12) leads to

$$\frac{1}{c_t} = \frac{\beta}{c_{t+1}}(1-\delta_c + r_{c,t+1}) \tag{39}$$

2.3. Firm's problem in the CM

A firm producing general goods faces the following profit maximization problem.

$$\max_{h_{ns,t},\, h_{s,t},\, k_{c,t},\, k_{nc,t}} \left\{ \begin{array}{l} h^{\gamma}_{ns,t}\left[\lambda h^{\rho}_{s,t} + (1-\lambda)k^{\rho}_{c,t}\right]^{\frac{\chi}{\rho}} k^{1-\gamma-\chi}_{nc,t} \\ -w_{ns,t}h_{ns,t} - \underline{w}h_{s,t} - r_{c,t}k_{c,t} - r_{nc,t}k_{nc,t} \end{array} \right\} \tag{40}$$

The first-order conditions in terms of $h_{ns,t}$, $h_{s,t}$, $k_{c,t}$, and $k_{nc,t}$ are

$$\gamma h^{\gamma-1}_{ns,t}\left[\lambda h^{\rho}_{s,t} + (1-\lambda)k^{\rho}_{c,t}\right]^{\frac{\chi}{\rho}} k^{1-\gamma-\chi}_{nc,t} = w_{ns,t} \tag{41}$$

$$h^{\gamma}_{ns,t}\chi\left[\lambda h^{\rho}_{s,t} + (1-\lambda)k^{\rho}_{c,t}\right]^{\frac{\chi}{\rho}-1} \lambda h^{\rho-1}_{s,t} k^{1-\gamma-\chi}_{nc,t} = \underline{w} \tag{42}$$

$$h_{ns,t}^{\gamma}\chi\left[\lambda h_{s,t}^{\rho}+(1-\lambda)k_{c,t}^{\rho}\right]^{\frac{\chi}{\rho}-1}(1-\lambda)k_{c,t}^{\rho-1}k_{nc,t}^{1-\gamma-\chi}=r_{c,t} \tag{43}$$

$$h_{ns,t}^{\gamma}\left[\lambda h_{s,t}^{\rho}+(1-\lambda)k_{c,t}^{\rho}\right]^{\frac{\chi}{\rho}}(1-\gamma-\chi)k_{nc,t}^{-\gamma-\chi}=r_{nc,t} \tag{44}$$

2.4. Market clearing conditions in the CM

In accordance with Walras law, the clearing conditions regarding the labor market, capital market, and money market are taken into account. First, the labor market clearing conditions are $h_{ns,t}=\alpha h_t^s$ and $h_{s,t}=(1-\alpha)h_t^s$. Second, the capital market clearing conditions are $k_{nc,t}=k_{nc,t}^s$ and $k_{c,t}=k_{c,t}^s$. Third, the money market is $\hat{m}_t=1$.

2.5. Equilibrium

Now it is possible to define the equilibrium of the model. This equilibrium involves a collection of sequences $\left\{\begin{matrix} c_t,\ \hat{m}_{t+1},k_{nc,t+1}^s,k_{c,t+1}^s,i_{nc,t},i_{c,t},h_t^s,h_{ns,t},h_{s,t}, \\ k_{nc,t},k_{c,t},y_t,q_t,\tilde{q}_t,\hat{\ell}_t,w_{ns,t},r_{nc,t},r_{c,t},\hat{p}_t \end{matrix}\right\}_0^{\infty}$, given that the constraint conditions, the first-order conditions, and the market clearing conditions hold. The steady state for each endogenous variable is taken into account, and is regarded as its initial value.

3. Calibration

3.1. Parameters

This study calibrates its parameters to match the observations made in South Korea. To do this calibration, a model is proposed that covers a period of one year. Table 1 shows the selected parameter values.

According to a Statistics Korea survey of the economically active population, the number of non-simple laborers in 2016 was 22,969 thousand, and that of simple laborers was 3,440 thousand. Thus, the share of non-simple labor α is 0.87. The discount factor β is set to 0.985 by using the real interest rate in 2016, as obtained from World Development Indicators. The value of 0.00972, which is the inflation rate in 2016 (as obtained from World Economic Outlook Database of the IMF), is chosen as the growth rate of the money supply τ.

Kim and Heo (2014) showed that the elasticity between labor and ICT capital is 1.8475. Following the literature, a parameter regarding the elasticity between the simple labor demand and the computer capital demand ρ is set to 0.459 ($\varphi = 1.8475$). According to a 2016 Statistics Korea survey of household income and expenditure, the average consumption propensity is 71.1%. This propensity can serve as a proxy for the probability of being a buyer, because it indicates the share of consumption expenditure in disposable income. Thus, the probability of being a buyer or a seller, σ, is determined as 0.711. The depreciation rates for non-computer capital δ_{nc} and for computer capital δ_c are set to 0.056 and 0.204, respectively, following Eden and Gaggl (2014).

According to the 2016 data obtained from the Bank of Korea, the capital share is 0.358. Following the capital share, the parameter regarding the non-computer capital share ψ is calibrated to 1.558. The technical parameter b for meeting the condition $u(0)=0$ is set to 0.0001, following Aruoba et al. (2011). As funding costs are treated as equal to the interest costs for credit card debt in this study, the interest rate for credit card debt ε is 0.0262, following the average funding rate of 2.62% that was offered by the Credit Finance Association of Korea in 2016.

According to the statistics of the Bank for International Settlement, the average annual payment via credit cards for each individual is 10,413.4 dollars (12,084,751 won). A buyer pays some of the interest costs of credit card debt in the form of annual credit card membership fees. The average annual fee for credit card membership is about 8,775 won, according to the data provided by FINDA.[6] Thus, the distributing parameter regarding interest costs for credit card debt ν is derived as 0.028. According to the data obtained from the Bank of Korea for 2016, the labor share is 0.642. The importance of non-simple labor γ and the total importance of simple labor

[6] FINDA is a company that provides information on domestic credit cards. The data are collected through a number of convenient financial products.

χ are set to 0.559 and 0.083, respectively, through a simultaneous consideration of both α and the labor share.

The parameters regarding the bargaining power of a buyer θ, labor supply A, the share of simple labor λ, and the rest of the costs (other than the funding costs in the credit card processing fees) η are all difficult to observe. Thus, their values are indirectly derived through targeted data, as shown in Table 2. The bargaining power of a buyer θ is set to 0.999, to match the observation of 0.45, which is the ratio of money as a means of payment to all means of payments.[7] The ratio ω derived from the model, 0.44, is similar to that produced by the data. Note that if $\theta = 1$, a seller cannot obtain any gain from trading. Thus, the seller cannot pay a credit card processing fee for a credit card payment service in that case. For this reason, the condition for the existence of an equilibrium in this model is that $\theta < 1$. Parameters A and λ are set to 2.136 and 0.53, respectively, to match the value of 1.94, which is the ratio of the average monthly regular salary for non-simple labor (2,968 thousand won) to that for simple labor (1,526 thousand won).[8] The ratio produced by the model, 1.98, is similar to that produced by the data. Parameter η is set as 0.35, to match the

[7] According to a 2016 report regarding the various means of payment (as indicated by the Bank of Korea), 55% of all payments were made using credit cards. Only 45% of all payments were made by other means such as cash, debit cards, check cards, or electronic money. This study regards means of payment other than credit cards as “money” in a broad sense.
[8] The 2016 survey on work status by employment type (conducted by the Ministry of Employment and Labor) includes data regarding the average monthly regular salary.

observation of 0.08, which is the ratio of funding costs (0.9 trillion won) to credit card processing fees (11.1 trillion won).[9] The model produces the similar value of 0.09.

<Insert Table 1>

<Insert Table 2>

3.2. Results

Let us examine the steady state of a model economy with both a 13.6% hike in minimum wage and a 0.65% reduction in the credit card processing fee as compared to the steady state of a model economy without these events.[10]

First, we compare the steady state of a model economy with a 13.6% hike in the minimum wage with that of a model economy without this event. The 13.6% hike in the minimum wage produces a 16.461% reduction in demand for simple labor (which is subject to the minimum wage). At the same time, computer capital demand increases by 6.432%. In other words, the increase in the minimum wage expedites computerization. This result is consistent with the current phenomenon. Following the big jump in the minimum wage in 2018, the demand for unmanned machines such as

[9] The Financial Supervisory Service records data from 2016 regarding credit card processing fees, and the Credit Finance Association of Korea reports the data regarding funding costs.
[10] The average of rate of increase in the minimum wage for the years 2018 and 2019 is 13.6%.

kiosks, self-service gas pumps, and CCTV increased significantly.[11] As the total simple labor (derived from combining simple labor and computer capital) is relatively complementary to non-simple labor and non-computer capital, it is clear that the demand for non-simple labor and non-computer capital has shrunk by 0.157% and 1.501%, respectively. Accordingly, the production and consumption of general goods decreased by 1.501% and 1.175%, respectively. Note that minimum wage hikes negatively and significantly affect overall employment. This result is contrary to the literature. As mentioned above, the use of a general equilibrium model to examine the relationship between minimum wage increases and job automation combined with a long-run approach in the quantitative analysis is responsible for this difference in result relative to previous studies.

In the model economy, wages for non-simple labor decrease by 1.346% in accordance with the market clearing condition. In contrast, the prices for general goods (denominated in dollars) increase by 2.431%, following the reduction in consumption of general goods (according to Equation (37)). The price for non-computer capital decreases by 0.0001%, whereas the price for computer capital does not change. The reason for the difference between these prices is that in the DM, there is only a need

[11] According to the Korea National Oil Corporation, the rate of increase in the numbers of self-service gas stations was 3.9% in 2015, 1.4% in 2016, 2.2% in 2017, and 5.2% in 2018.

for non-computer capital. Total sales increase by 0.849% due to the significant hike in the price of general goods (denominated in dollars).[12]

<Insert Table 3>

Second, let us compare the steady state of a model economy with a 0.65% reduction in credit card processing fees with that of a model economy without this event. The 0.65% reduction in the credit card processing fee is accomplished by changing the buyer's burden of interest on credit card debt from 2.8% to 10%. The 0.65% reduction in credit card processing fees decreases the credit card debt by 0.195%, and reduces the quantity of goods purchased through credit cards by 0.032%. The quantity of goods purchased with money is expected to increase following the reduced quantity of goods purchased with credit cards. However, the total goods purchased with money decreases by 0.027%, because the positive effect of wages for non-simple labor overwhelms the negative effect of the price for general goods (denominated in dollars), as indicated in Equation (26). The consumption of general goods is slightly affected by the change in wages for non-simple labor, in accordance with Equation (9). In turn, the capital supply decreases, and the corresponding capital demand and investment in

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12 Total sales are equal to $\hat{p}_t y_t + \sigma\left[\omega \hat{m}_t + (1-\omega)\hat{\ell}_t\right]$, consistent with Aruoba et al. (2011).

capital are both reduced. In addition, the labor supply shrinks as the credit card debt decreases, because wage income is less necessary for liquidating the debt. Thus, the corresponding labor demand goes down. The reduction of these inputs results in a 0.089% decrease in the production of general goods. The prices for general goods (denominated in dollars) decrease by 0.008%, in accordance with Equation (37). On the basis of these results, it is determined that total sales shrink by 0.103%. Note that the reduction in the credit card processing fee (derived from shifting the burden of interest costs for credit card debt from seller to buyer) causes a fall in total sales. This outcome demonstrates a typical feature of a two-sided market regarding the credit card payment system.

<Insert Table 4>

Third, let us compare the steady state of a model economy with both a 13.6% hike in minimum wage and a 0.65% reduction in the credit card processing fee with that of a model economy without either of these events. We find that these two events result in reductions in the consumption and production of general goods by 1.175% and 1.589%, respectively. With respect to production inputs, the demand for simple and non-simple labor decreases by 16.536% and 0.246%, respectively, and the demand for computer capital rises considerably by 6.338%. Note that the effect on employment of the minimum wage hike and reduced credit card processing fees both work in the same direction, and both effects are negative. This implies that although the policy of reducing credit card processing fees was adopted to ease the negative effect of the minimum wage hike on employment, the reduction in credit card processing fees decreases labor demand. Prices for general goods (denominated in dollars) jump by 2.423%, mainly due to the hike in the minimum wage.

<Insert Table 5>

3.3. Robustness tests

Table 6 presents the results of the robustness tests for the main exercise. This study compares the steady state of a model economy with both a 13.6% minimum wage hike and a 0.65% reduction in credit card processing fee with that of a model economy without either of these events. As the ρ value is set in accordance with the literature, the main result may be sensitive to the choice of value. The result for $\rho = 0.091$ ($\varphi = 1.1$) is very similar to the benchmark case except for computer capital demand. The sign for computer capital demand is negative, unlike the benchmark case. This difference is explained by the decrease in elasticity between the simple labor demand and the computer capital demand from $\varphi = 1.8475$ to $\varphi = 1.1$. The result for $\rho = 0.667$ ($\varphi = 3$) is consistent with the benchmark case. As the average consumption propensity is used as a proxy for the probability of being a buyer or a seller σ, the result for the benchmark case may be sensitive to the choice of value. The results for $\sigma = 0.1$ and $\sigma = 0.9$ are very similar to the benchmark case. As the value of δ_c follows the literature, the robustness test for this parameter is also vital. The results for $\delta_c = 0.056$ and $\delta_c = 0.5$ are consistent with the benchmark case. As the values of θ, λ, and η are derived indirectly through targeted data, robustness tests are needed. As shown in Table 6, they are not sensitive to the choice of their value.

<Insert Table 6>

4. Conclusion

Several meaningful findings emerge from the calibration of effects from a minimum wage hike and a reduction in credit card processing fees. A rapid increase in the minimum wage negatively and significantly affects overall employment. In particular, it leads to a significant reduction in demand for simple labor, which is affected by the minimum wage. In addition, the increase expedites both computerization and a rise in the price of goods. The reduction in the credit card processing fee, which is derived from shifting the burden of credit card interest costs from seller to buyer, induces a decline in credit card debt and a fall in total sales. Note that this finding demonstrates a typical feature of a two-sided market with a credit card payment system. The calibrated results for these two polices show that although the reduction in credit card processing fees is adopted to ease the negative effect on employment of the minimum wage hike, the reduction in credit card processing fees results in decreased labor demand.

This study leaves room for further research. As it assumes that the presence of a credit card company is given exogenously, future studies can consider the roles these companies play more explicitly. More detailed examinations can be made by dividing general goods into intermediate goods and final goods. With respect to the intermediate goods, the concept of span of control (as introduced by Lucas (1978)) can be added. Thus, future studies can deal with endogenous size distributions among production units.

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Table 1 Parameter values.

Parameter	Definition	Value
α	Share of non-simple labor	0.87
β	Discount factor	0.985
τ	Growth rate of money supply (Inflation rate)	0.00972
ρ	Parameter regarding the elasticity between simple labor demand and computer capital demand	0.459
σ	Probability of being a buyer or a seller	0.711
δ_{nc}	Depreciation rate for non-computer capital	0.056
δ_{c}	Depreciation rate for computer capital	0.204
ψ	Parameter regarding non-computer capital share	1.558
b	Technical parameter for meeting the condition	0.0001
ε	Interest rate for credit card debt	0.0262
ν	Distributing parameter regarding interest costs for credit card debt	0.028
γ	Importance of non-simple labor	0.559
χ	Importance of total simple labor	0.083
θ	Bargaining power of a buyer	0.999
A	Parameter regarding labor supply	2.136
λ	Share of simple labor	0.53
η	Costs other than the funding costs in credit card processing fees	0.35
$\underline{w}$	Minimum wage	0.1

Table 2 Calibration targets.

Statistics	Data	Model
Ratio of money as a means of payment to all means of payments	0.45	0.44
Ratio of the average monthly regular salary of non-simple labor to that of the salary for simple labor	1.94	1.98
Ratio of funding costs to credit card processing fees	0.08	0.09

Table 3 Result from a 13.6% hike in the minimum wage.

Variables	Change in rate (%)
Simple labor demand	-16.461
Computer capital demand	6.432
Investment in computer capital	6.432
Non-simple labor demand	-0.157
Non-computer capital demand	-1.501
Investment in non-computer capital	-1.501
Production of general goods	-1.501
Consumption of general goods	-1.175
Wages for non-simple labor	-1.346
Price for general goods (denominated in dollars)	2.431
Price for non-computer capital	-0.0001
Price for computer capital	No change
Total sales	0.849
Quantity of goods traded through money	-0.564
Quantity of goods traded through credit cards	-0.540
Credit card debt	0.894

Table 4 Results of a 0.65% reduction in credit card processing fee.

Variables	Changing rate (%)
Credit card debt	-0.195
Quantity of goods traded through credit cards	-0.032
Quantity of goods traded through money	-0.027
Consumption of general goods	0.000
Non-computer capital demand	-0.089
Computer capital demand	-0.089
Investment in non-computer capital	-0.089
Investment in computer capital	-0.089
Non-simple labor demand	-0.089
Simple labor demand	-0.089
Production of general goods	-0.089
Wages for non-simple labor	0.001
Price for general goods (denominated in dollars)	-0.008
Price for non-computer capital	-0.0001
Price for computer capital	No change
Total sales	-0.103

Table 5 Results for both a 13.6% hike in minimum wage and a 0.65% reduction in credit card processing fee.

Variables	Changing rate (%)
Consumption of general goods	-1.175
Production of general goods	-1.589
Non-simple labor demand	-0.246
Simple labor demand	-16.536
Non-computer capital demand	-1.589
Computer capital demand	6.338
Price for general goods (denominated in dollars)	2.423
Credit card debt	0.698
Quantity of goods traded through credit cards	-0.572
Quantity of goods traded through money	-0.590
Investment in non-computer capital	-1.589
Investment in computer capital	6.338

Wages for non-simple labor	-1.346
Price for non-computer capital	-0.0001
Price for computer capital	No change
Total sales	0.745

Table 6 Robustness tests

(1) Results for parameters ρ, σ, and δ_c

Variables	Changing rate (%)					
	ρ		σ		δ_c	
	0.091	0.667	0.1	0.9	0.056	0.5
Consumption of general goods	-0.896	-1.483	-1.175	-1.175	-0.754	-1.415
Production of general goods	-1.253	-1.947	-1.552	-1.590	-1.158	-1.847
Non-simple labor demand	-0.189	-0.297	-0.208	-0.247	-0.251	-0.257
Computer capital demand	-0.537	22.820	6.377	6.336	4.140	7.592
Price for general goods	1.837	3.074	2.667	2.416	1.539	2.930
Credit card debt	0.487	0.931	0.992	0.689	0.365	0.892
Wages for non-simple labor	-1.066	-1.655	-1.347	-1.347	-0.910	-1.594
Total sales	0.525	0.996	1.069	0.725	0.343	0.965

(2) Results for parameters θ, λ, and η

Variables	Changing rate (%)					
	θ		λ		η	
	0.4	0.7	0.3	0.8	0.1	0.6
Consumption of general goods	-1.169	-1.169	-0.372	-1.686	-1.175	-1.175
Production of general goods	-1.553	-1.560	-0.675	-2.158	-1.474	-1.682
Non-simple labor demand	-0.219	-0.224	-0.136	-0.315	-0.130	-0.340
Computer capital demand	6.377	6.369	2.441	8.858	6.461	6.237
Price for general goods	2.833	2.580	0.752	3.504	2.424	2.421
Credit card debt	1.370	1.086	0.089	1.062	0.912	0.556
Wages for non-simple labor	-1.337	-1.338	-0.538	-1.850	-1.346	-1.346
Total sales	1.293	1.028	0.071	1.174	0.846	0.656