Regular and Non-regular Workers Substitutability and Policy Implications in South Korea*

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Abstract

I explore the effects of policies that affect relative prices between regular and non-regular workers in South Korea. To this end, I first estimate the constant elasticity of substitution (CES) production function using the Korean workplace level panel data. The implied elasticity of substitution implies that regular and non-regular workers are substitutes. Based on the empirical estimate, I implement policy experiments and counter-factual analysis using the calibrated heterogeneous firm model. The model is rich as it calibrates both firing and hiring costs, which are crucial factors of determining relative prices between regular and non-regular workers. Policy experiments imply that it is crucial to consider the degree of substitution and labor adjustment costs.

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1 Introduction

Since non-regular workers have relatively lower earnings and job stability than regular workers, the Korean government has tried to resolve the issues of labor market duality. However, even though most of policies have affected the relative prices between regular and non-regular workers, there has been less literature to study the degree of substitution between them. For instance, if the government reduces burdens for social insurance payments for regular workers, it makes the relative price of regular workers be lower. In order to evaluate its effects quantitatively, it is crucial to know the degree of substitution between regular and non-regular workers.

This paper aims to answer the following questions. First, are regular and non-regular workers substitute or complements? Second, given the elasticity of substitution, how do taxes and the firm's burden of social security insurance affect the employment of regular and non-regular workers? To this end, I first estimate the constant elasticity of substitution (CES) production function to evaluate the elasticity of substitution between regular and non-regular workers in Korea using the Workplace Panel Survey (WPS) data. Using the empirical estimates, I calibrate the heterogeneous firm model with rich features to study the policy implications of tax and the firm's burdens on social security policies. The structural model has both costs of hiring and firing in regular employment, which are hard to investigate in a reduced-form empirical analysis. Those features are helpful to explore policy implications more accurately.

Main results are as follows. First, the empirical estimate of the elasticity of substitution implies that regular and non-regular workers are substitutes. More precisely, the reduced-form analysis implies that the employment of regular workers increases by $2.72 \sim 3.21\%$ if the relative labour cost of regular workers decreases by 1%. To estimate the elasticity of substitution, I estimate the parametric CES production non-linearly rather than linearly approximated function. The result is robust whether or not I consider the elasticity of substitution of physical capital in the CES production function.

Using the structural model, I find that the fraction of regular employment increases by 0.4% and 0.6% with respect to 10% increase of social insurance payment for non-regular workers and 10% decrease of it for regular workers, respectively. That is, if policies which make non-regular (regular) workers be more (less) expensive increase the fraction of regular workers. Furthermore, more interestingly, I show that (exogenous) policies affect relative prices have different distributional and output efficiency outcomes, which depend on the degree of substitution. If regular and non-regular workers are complements in the counter-factual study, the changes of regular and non-regular workers are less than the case of benchmark model. For example, if the firm has pay insurance payment for non-regular workers more, they fire non-regular workers much less if non-regular and regular workers are complements. However, as the firm fires regular workers relatively more, the output decreases more either.

The main contributions of this paper are as follows. First, to my best knowledge, this is the first paper to estimate the CES production function, and thus the elasticity of substitution between regular and non-regular workers using the workplace level panel data. Second, to evaluate the quantitative effects of various government policies to try to resolve the issue of labor market duality, this paper builds and calibrates the structural heterogeneous firm model. Even though the recent literature considers the imperfect substitutability in the production function since Krusell et al. (2000)'s influential work, the most of literature has tried to calibrate, rather than to estimate. In the context of regular and non-regular workers, Miyamoto (2016) studies the structural macro model with search frictions to investigate how productivity growth affects the share of non-regular employment. Chang et al. (2016) explores how employment, labor productivity, and output would be changed if firms could hire only regular or non-regular workers in the Korean economy using the Diamond-Mortensen-Pissarides model. However, none of the studies take into account the imperfect substitution between regular and non-regular workers.[1] As this paper studies both a reduced-form estimate and policy experiments using the heterogeneous firm model, it sheds light on the policy

[1]Miyamoto (2016) considers the CES production theoretically but the paper solves the model with the Cobb-Douglas production function.

implications in the dual labor market.

The paper consists of as follows. Section 2 discusses the empirical analysis of estimating the elasticity of substitution between regular and non-regular workers. Section 3 and Section 4 study the structural heterogeneous firm model and the policy experiments using the structural model. Section 5 concludes the paper.

2 Empirical Analysis: Elasticity of Substitution

In this section, I estimate the CES production function, and thus the elasticity of substitution between regular and non-regular workers using the Workplace Panel Survey (WPS). The empirical analysis has two novel features. First, I estimate the CES production function using firm-level financial data, rather than estimating the relationship between relative employment of regular and non-regular workers and relative earnings. It is beneficial to estimate the whole CES production function as it is more straightforward to use estimates in the analysis of the structural model and to control for other financial conditions of workplaces.

And I estimate the CES function non-linearly instead of estimating its linear approximation as in Kmenta (1967). It is well known that the non-linear estimation of CES production function might be unstable. This is also true in this analysis. However, it cannot be a better option to estimate linearly approximated function as it performs well only when the true elasticity of substitution is close to zero, which implies the Cobb-Douglas production function. And if there are more than two production factors, such as regular employment, non-regular employment, and capital, we cannot achieve the Taylor first-order approximation. That is, the non-linear estimation would be more flexible if the researcher would consider more production factors. Thus, I estimate the CES production function non-linearly.

I first introduce the WPS and argue why it is the best microdata to estimate the CES production function. Above all, among all workplace level data, it gives us to measure the number of non-regular and regular employment most accurately. And I introduce the empirical framework and results of estimation.

2.1 Data: Workplace Panel Survey (WPS)

The Workplace Panel Survey (WPS) is a survey approved by the Korean government and conducted by the Korea Labor Institute. The first wave was sampled in 2002 and the second wave was done in 2003. Workplace Panel Survey 2005 (WPS 2005) was newly sampled in 2005 and is to be used for the subsequent biyearly surveys. The recent survey at this stage is 9th wave, thus it covers from 2002 to 2019. And the WPS additionally collects samples to compensate sample attrition due to firm exit or other reasons in December 2014. As the result, the WPS has financial and employment information for 13,831 samples.

I use the WPS because it is the best microdata for the purpose of this research. In order to estimate the CES production function, we need both financial and employment information at workplace level. That is, as the dependent variable and control variables, we need the value of revenue or value-added for each firm, cost of goods sold (COGS, hereafter), selling, general and administrative expenses (SG&A, hereafter) or capital measured by property, plant and equipment (PPE). Also, more crucially, we need to measure the number of non-regular and regular employment. The WPS is the only workplace level panel data which satisfies both two conditions among all workplace level panel data.

The WPS has following limitations either. First, it covers only workplaces with 30 or more employees. That is, it would over-represent large firms. Second, the survey is bi-annual. Thus, it would not be a good choice to study business cycle fluctuations. However, I argue that the above shortcomings would have limited effects in this analysis. Since the purpose of research is to estimate the elasticity of substitution between regular and non-regular workers, it naturally excludes workplaces of too small size. Furthermore, the high frequency variations of employments or financial conditions would not be essential to identify the elasticity of substitution.

Measure of Employment The WPS provides employment information in detail. Since the questionnaire of WPS has been changed slightly for some wave, I measure the total employment, non-regular employment and regular employment as follows. For total employment from 2005 to 2013, I add the number of all employees (epq1011), foreign employees (epq6005), employment from subcontractors (epq9008), work-at-home workers (epq9903) and other employees (epq9906). From 2015 to 2019, the number of total employment is measured by the summation of the number of all employees (epq1011) and the sum of employment from subcontractors (epq9008).

The benefit of WPS is to allow us to measure the number of non-regular employment based on its formal definition suggested by the Korean government. From 2005 to 2013, the measure of non-regular employment is to add the number of fixed-term workers (epq5028), part-time workers (epq5038), foreign workers (epq6005), employment from subcontractors (epq9008), work-at-home workers (epq9903) and other employees (epq9906). From 2015, the number of non-regular workers is measured by the summation of directly-employed non-regular workers (epq5008) and indirectly-employed non-regular workers (epq9008).[2]

For regular employment, the WPS directly asks the number of it directly from 2015. Before 2015, I measure the number of regular employment as the difference between the number of total employment and the number of non-regular employment.[3]

Financial Variables As the dependent variable, I use the revenue for each workplace, which is the average of current and the one-period before revenues (fpq2001 and fpq2002). I also use the COGS (Cost of Goods Sold, fpq2004), SG&A (Selling, General and Administrative Expenses, fpq2005) and PPE (Property, Plant and Equipment, the average of fpq4003 and fpq4004). All of financial variables are normalized by the Consumer Price Index (CPI) with 2015 base-year.[4]

[2] See Kim et al. (2018, 2020) (in Korean) for more details.

[3] Theoretically, it might not be correct. However, as the robustness check, I find that the estimation results between for the period of $2015 - 2019$ and for the whole sample period are not statistically different.

[4] Unlike the employment information, the financial information could be based on firm-level, not the

Sample Criteria I exclude the samples which have zero or negative revenues, COGS or SG&A. Also, I also exclude the sample if the sum of regular workers and non-regular workers is greater than the total employment. The most strong restriction is that I include only samples which have positive values for both regular and non-regular workers.

2.2 CES Production Function: Estimation

Using the WPS sample, this paper aims to estimate the CES production function. Theoretically, the workplace j's output Y at t is presented by the following parametric functional form.

$$Y_{jt} = z_{jt} \left[\alpha n_{r,jt}^{\rho} + (1-\alpha) n_{nr,jt}^{\rho}\right]^{\frac{\nu}{\rho}} \tag{1}$$

where z is the workplace j's productivity, α is the relative share of regular workers in production, n_r is the regular employment, n_{nr} is the non-regular employment, ν is the parameter of return to scale and $\sigma = 1/(1-\rho)$ is the measure of elasticity of substitution between regular and non-regular workers.

The key parameter is ρ, which represents the elasticity of substitution $\sigma = 1/(1-\rho)$ under the specification of (1). If $\rho = 1$, it implies that regular and non-regular workers are perfect substitutes as the production function becomes linear. If $\rho = 0$, it converges to the Cobb-Douglas production function $Y = z n_r^{\alpha} n_{nr}^{1-\alpha}$. If $0 < \rho < 1$, it implies that regular and non-regular workers (imperfect) substitutes. Lastly, if $\rho < 0$, it means that regular and non-regular workers are gross complements. Empirically, it could be estimated by the following non-linear regression.

$$\log Y_{jt} = \log z_{jt} + \frac{\nu}{\rho} \log \left[\alpha n_{r,jt}^{\rho} + (1-\alpha) n_{nr,jt}^{\rho}\right] + \varepsilon_{jt} \tag{2}$$

workplace level. Thus, I adjust them using the method suggested by the User Guide of WPS (in Korean).

where log represents a natural logarithm and ε is an error term. Obviously, the above regression specification could have omitted variable bias and endogeneity issue. However, because of computational instability, it is hard to control other financial variables in (2). Thus, in order to overcome the issue, I estimate the CES function as follows. For the first step, I run the following regression.

$$\log Y_{jt} = \gamma \log X_{jt} + \lambda_j + e_{jt} \tag{3}$$

where X includes control variables such as COGS, SG&A, PPE or workplace age, λ_j represents the workplace j specific fixed effect and e is an error term. From (3), I extract the residual $\hat{e}$ and use it in the following second step regression.

$$\hat{e}_{jt} = \beta_0 + \frac{\nu}{\rho} \log \left[\alpha n_{r,jt}^{\rho} + (1-\alpha) n_{nr,jt}^{\rho}\right] + \varepsilon_{jt} \tag{4}$$

Linearization As in Kmenta (1967), the CES production function in (1) can be linearized by Taylor first order approximation as follows.

$$\log Y_{jt} = \beta_0 + \beta_1 \log n_{r,jt} + \beta_2 \log n_{nr,jt} + \beta_3 \left(\log n_{r,jt} - \log n_{nr,jt}\right)^2 + \gamma \log X_{jt} + \lambda_j + \varepsilon_{jt} \tag{5}$$

where $\beta_1 = -\nu\alpha$, $\beta_2 = -\nu(1-\alpha)$ and $\beta_3 = -0.5\nu\rho\alpha(1-\alpha)$. It seems that it allows to estimate the CES production function more flexibly and all parameters could be clearly identified in linear. However, as shown in literature, this approximation does hold only when $\rho \to 0$, which implies that the CES production function converges to the Cobb-Douglas production function. Furthermore, this approximation is not available if the function has one more production factor, such as capital. Thus, I report only the results of non-linear estimation.

2.3 Estimation Results

Table 1 shows the result of CES production function estimation. First, I estimate it for the period of $2015-2019$ and the whole period separately, I measure the number of regular employment discretionary. For both ρm the elasticity of substitution and α, the share of regular employment, the results are not statistically different. As shown in Model 1 and Model 3, the empirical estimate of elasticity of substitution is on $\rho \in [0.633, 0.689]$. Model 2 and Model 4 represent results when we do not control for COGS and SG&A, which are usually interpreted as variable costs and fixed costs, respectively. They imply the importance of controlling the financial variable as 1) standard errors of coefficients are higher than those in Model 1 or Model 3, and 2) implied elasticity of substitution $\sigma = 1/(1-\rho)$ is not statistically significant.[5] Thus, the estimates in Model 1 and Model 3 are benchmark results. They imply that the employment of regular workers increase 2.72∼3.21% relatively than non-regular workers if the relative price of regular workers decreases by 1%.[6]

Extended Model: Capital As a robustness check, instead of controlling capital (PPE) in the first stage of regression, I estimate the extend CES production function as follows.

$$Y_{jt} = z_{jt}\left[\phi\left(\lambda k_{jt}^{\gamma} + (1-\lambda)n_{r,jt}^{\gamma}\right)^{\frac{\rho}{\gamma}} + (1-\phi)n_{nr,jt}^{\rho}\right]^{\frac{\nu}{\rho}} \tag{6}$$

where k is PPE, physical capital. In the specification of (6), the elasticity of substitution between regular employment n_r (or capital k) and non-regular employment n_{nr} is still $\sigma = 1/(1-\rho)$. With the similar methods, I estimates (6) with two-stage estimation.

Table 2 shows the results to estimate (6) for the period of $2015-2019$ and the whole period. As shown in (6), results are not very different with the benchmark result in Table 1.

[5]For example, σ in Model 2 is around 49.5866 and even it is greater than unity, which is not intuitive in economic theory.

[6]I also estimate the linearized CES production in (5). However, for all specifications I have tried, ρ and α are statistically insignificant and results are more unstable than results in Table 1. Results are available upon request.

Estimation: CES Production Function				
	Period: 2015 − 2019		Whole Period	
	Model 1	Model 2	Model 3	Model 4
ρ: $\sigma = \frac{1}{1-\rho}$, Elasticity of Substitution	0.689***	0.980***	0.633***	1.147***
	(0.0723)	(0.125)	(0.057)	(0.146)
α : Share of Regular Employment	0.579***	0.539***	0.554***	0.455***
	(0.0165)	(0.0226)	(0.015)	(0.0273)
Control at the First Stage: PPE	Yes	Yes	Yes	Yes
Control at the First Stage: COGS	Yes	No	Yes	No
Control at the First Stage: SG&A	Yes	No	Yes	No
Workplace Level Fixed Effect	Yes	Yes	Yes	Yes
# of Samples	2,603	2,693	3,753	3,953

Note: Standard error in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1: Benchmark Result: Estimates of CES Production Function (4) using WPS. PPE means Property, Plant and Equipment, COGS means the Cost of Goods Sold, and SG&A means Selling, General and Administrative Expenses.

CES Production Function Estiation: With Capital				
	Period: 2015 − 2019		Whole Period	
	Model 1	Model 2	Model 3	Model 4
Elasticity of Substitution (σ)	3.1185***	2.1448***	2.3593***	2.1670***
	(0.6940)	(0.3046)	(0.2859)	(0.2687)
Control at the First Stage: COGS and SG&A	Yes	No	Yes	No

Note: Standard error in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Extended Model: Estimates of CES Production Function with capital using WPS. The parameter $\sigma = 1/(1-\rho)$ implies the elasticity of substitution between regular employment/capital and non-regular workers. COGS means the Cost of Goods Sold and SG&A means Selling, General and Administrative Expenses. Full estimation table is available upon request.

Furthermore, unlike in the benchmark specification, the estimates of σ are stable whether or not we control for COGS and SG&A in the first stage.

3 Structural Model

I build and calibrate a structural model of heterogeneous firm with both firing and hiring costs. It is beneficial to investigate the structural model as it allows to to study flexible policy experiments or counter-factual studies with theoretical channels, which would be hard to be done in the reduced-form analysis.

One novel feature of the model is that the model considers both firing and hiring costs. Once the firm hires a regular worker, it is costly to fire the worker because of severance pay, litigation costs, administrative costs or etc by construction. Therefore, the firms would be much more picky to hire regular workers than non-regular workers whose firing cost is much lower than regular workers. This is the reason why the distortion of employment protection policy is severe in the heterogeneous firm model, as shown in Hopenhayn and Rogerson (1993)'s influential work. Thus, I calibrate the firing cost to match the data. Also, I calibrate the hiring cost separately, which can indirectly allow us to consider the search friction.[7]

3.1 Environment

Time Time is discrete and infinite, and the time frequency is monthly.

Market I assume that the goods market is perfectly competitive without any friction and the price of goods $p = 1$, which implies that the consumption good or output is a numeraire. For the labor market, there exists adjustment costs for both firing c_- and hiring c_+, which are the portion of wage payment. Without loss of generosity, I assume that there are labor adjustment costs only for regular workers.

Agent In the economy, there are heterogeneous firms indexed by the size, which is the

[7] Elsby and Michaels (2013) and Elsby et al. (2019) build heterogeneous firm models under search frictions with labor adjustment costs.

endogenous state variable and productivity, which is the exogenous state variable. Since there exists adjustment costs for regular workers only, the endogenous state variable is the number of regular employment at the previous period. For each period, given the market wages for regular and non-regular workers W_r and W_{nr}, respectively, firms hire regular and non-regular workers to maximize the life-time profit. To be simple, I also assume that there is no capital in the production function.

Productivity As in the literature of heterogeneous firm model such as Hopenhayn and Rogerson (1993), Elsby and Michaels (2013) and Elsby et al. (2019), each firm has a stochastic productivity x which follows the first order Markov process (Auto-Regressive (AR(1)) process, hereafter). That is, given the current productivity x, the productivity at the next period x' is determined by as follows.

$$\log x' = \rho_x \log x + \varepsilon'_x, \qquad \varepsilon'_x \sim iid\mathbb{N}\left(0, \sigma_x^2\right) \tag{7}$$

Technology The firm who has n_r regular employees and n_{nr} non-regular employees produces output level y with the following CES production function:

$$y = xf\left(n_r, n_{nr}\right) = x\left[\alpha n_r^{\rho} + (1-\alpha)n_{nr}^{\rho}\right]^{\frac{\nu}{\rho}} \tag{8}$$

where α is the share of regular employment in production, $0 < \nu < 1$ is the parameter of return to scale, which is lower than unity in the heterogeneous firm model and ρ represents the elasticity of substitution between regular workers and non-regular workers $\sigma = 1/(1-\rho)$.

Wages The wages for regular workers W_r and non-regular workers W_{nr} are determined by the marginal productivity of aggregate regular employment $\int n_r(n_{r,-1}, x)d\mu(n_{r,-1}, x)$ and non-regular employment $\int n_{nr}(n_{r,-1}, x)d\mu(n_{r,-1}, x)$, respectively where $\mu(n_{r,-1}, x)$ is the distribution function in the stationary equilibrium.[8] Since the interest of this paper is to study

[8]If there is only one worker type as in Elsby and Michaels (2013), we could consider the wage function analytically which depends on the firm's state. However, once we consider both regular and non-regular workers, the analytical solutions such as $W_r(n_{r,-1}, x)$ or $W_{nr}(n_{r,-1}, x)$ are not available.

how effective labor costs of regular or non-regular workers affect for each employment, I simplify the wage determination.

Tax and Social Security The firm needs to pay corporate taxes with the rate τ. And the firm has to pay the social insurance payments − national pension, health insurance, industrial accident compensation insurance and employment insurance. Overall, the firm has to pay 10.71% of workers' earnings as the social insurance payment.

3.2 Value Function

Given wages W_r and W_{nr}, the firm $(n_{r,-1}, x)$ solves the following Bellman equation optimally to maximize the life-time value.

$$\pi(n_{r,-1}, x) = \max_{n_r, n_{nr}} \Big\{(1-\tau)\left[xf(n_r, n_{nr}) - W_r(1+s_r)n_r - W_{nr}(1+s_{nr})n_{nr} - \left(W_r c_+ \Delta n_r^+ + W_r c_- \Delta n_r^-\right)\right] + \beta \int \pi(n_r, x')dF(x'|x)\Big\} \tag{9}$$

where s_r is the social insurance payment for regular workers, s_{nr} is it for non-regular workers, $\Delta n_r^+ = \max\{0, n_r - n_{r,-1}\}$, $\Delta n_r^- = \max\{0, n_{r,-1} - n_r\}$, $\beta \in (0,1)$ is the time discount factor and $F(x'|x)$ is the cumulative distribution function of the next period productivity x' conditional on x.

As shown in (9), while the choice of hiring regular workers is an inter-temporal decision, it of hiring non-regular workers is an intra-temporal decision. This is because I assume that there exists adjustment costs only for regular workers. Even though hiring non-regular workers allows the firm to adjust employment more flexibly, the firm has an incentive to hire regular workers as they could contribute more in production. That is, the value of α is significantly greater than 0.5 in the calibration. As the result, although the adjustment costs decrease the marginal benefits of hiring regular workers, the equilibrium wage for regular workers could be greater than it for non-regular workers.

Parameter	Value	Description	Target/Source	Model
External Calibration				
ρ	0.6890	Elasticity of Substitution	Table 1	.
β	0.9963	Time Discount Factor	3-Year Treasury Yields	Monthly
τ	0.1600	Profit Tax	National Tax Statistics	
s_r	0.1071	Social Security Insurance for n_r	Korean Legislation	
s_{nr}	0.1071	Social Security Insurance for n_{nr}	Korean Legislation	
ρ_x	0.9740	AR(1) Process	Estimate	
σ_x	0.0786	Standard Deviation of Innovation	Estimate	
c_+^{SME}	0.0024	Hiring Cost for Small Firms	Report on Enterprise Labor Cost Survey	
c_+^{Large}	0.0076	Hiring Cost for Large Firms	Report on Enterprise Labor Cost Survey	
Internal Calibration				
α	0.7179	The Share of Regular Employment	$\mathbb{E}W_{nr}/W_r = 63.2833\%$	64.0000%
ν	0.7200	Return to Scale	$\mathbb{E}$[Total Employment]=8.7881	7.4821
c_-	1.0137	Firing Cost	$\mathbb{E}n_r = 6.2244$	6.2216

Table 3: Calibration

Using the novel features of the structural model, the imperfect substitution and labor adjustment costs, I implement two policy experiments in Section 4. First, I study the effect of the corporate tax deduction (lower τ). Second, I study the effect of the change of social insurance payments s_r or s_{nr} or the change of firing cost c_-. While the first policy changes the marginal costs of both regular and non-regular employment, the second one changes the relative prices of regular/non-regular workers. Since the technology in the model is the CES production which allows us to investigate the imperfect substitution, we can explore more interesting implications which would be muted in the case of Cobb-Douglas production function.

3.3 Calibration

Table 3 shows the result of calibrating the model. There are three parameters which are determined in the model to match the data and nine parameters which are determined in the outside of the model.

External Calibration The first key parameter is ρ, which represents the elasticity of substitution between regular and non-regular workers $\sigma = 1/(1-\rho)$. The value is $\rho = 0.6890$, which is the result of estimation in Table 1. It implies the elasticity of substitution $\sigma \approx 3.2154$ in the frictionless economy. And the time discount factor is $\beta = 0.9963$, which is based on the average 3-Year Treasury Bond in Korea from 2000 to 2019. The profit tax is $\tau = 0.1600$, the average corporate tax for 2015 and 2017. The social security payment rate of regular workers s_r is 10.71% of W_r, which is the sum of national pension, health insurance, industrial accident compensation insurance and employment insurance. In the benchmark model, it is the same for the it of non-regular workers, that is, $s_r = s_{nr} = 0.1071$.

And I estimate the persistence of a stochastic productivity x, ρ_x and the standard deviation of innovation shock ε_x, σ_x using the Korean Enterprise Data (KED). Since the WPS is a biannual data but KED is an annual firm-level panel which includes rich financial information, I use KED to estimate the productivity shock. Briefly, I estimate the production function using the method of Ackerberg et al. (2015) and transform it to monthly frequency.[9] As the result, the persistence of productivity shock is $\rho_x = 0.9740$ and the standard deviation of innovation is $\sigma_x = 0.0786$.

I also calibrate the cost of hiring regular workers using the *Report on Enterprise Labor Cost Survey* from 2010 to 2014. The *Report on Enterprise Labor Cost Survey*, which is surveyed by the Ministry of Employment and Labor, provides the information of recruiting cost, training cost and total labor compensation for each employee type at the workplace level. Thus, I calibrate the hiring cost as $c_+ =$(recruiting cost+training cost)/total labour compensation. Since the data allows to calibrate c_+ for small firms (employment is lower than 300) and large firms (employment is greater than or equal to 300), I calibrate $c_+^{SME} = 0.0024$ and $c_+^{Large} = 0.0076$.

Internal Calibration I first calibrate the share of regular employment in the production α to match the regular worker wage premium. In the *Survey report on labor conditions by employment type* surveyed by the Ministry of Employment and Labor, the wage of non-regular worker is 63.2833% of it of regular workers on average from 2008 to 2019.[10] Thus, the calibrated share of regular employment in the CES production is $\alpha = 0.7179$. In the model,

[9] See Kim et al. (2021) for more details.

[10] See `http://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx_cd=2478` (in Korean) for more details.

the ratio between non-regular worker wage and regular worker wage is $\mathbb{E}W_{nr}/W_r = 64.0000\%$, which fits the data well.

In addition, I calibrate the parameter of return to scale ν. As shown in Lucas (1978), it is necessary to consider the decreasing return to scale (DRS) production function in the heterogeneous firm model. That is, $\nu < 1$. I calibrate $\nu = 0.7200$ to match the average number of employee for each workplace 8.7881 using *The Establishment Status* surveyed by the Ministry of Employment and Labor from 2007 to 2019.[11] The implied moment $\mathbb{E}(n_r+n_{nr})$ in the model is 7.4821, which is lower than the data.

Lastly, I calibrate the firing cost $c_- = 1.0137$ to match the number of regular employment for each workplace in the data. It implies that the firm needs to pay 101.37% of wages additionally when they reduce the regular employment. The number of regular employment for each workplace in *The Establishment Status* from 2007 to 2019 is 6.2244. In the model, the implied moment $\mathbb{E}n_r = 6.2216$ in the model. Thus, while the model fits the number of regular workers well, it could not explain the number of non-regular workers very well.

4 Quantitative Exercises: Policy Experiments

Using a calibrated structural model, I implement policy experiments to investigate how policies which would affect the relative price of regular workers change the employment of regular/non-regular workers and aggregate economy.

Firstly, I compute the model when 1) the social security payment rate for regular employment s_r decreases and 2) the social security payment rate for non-regular employment s_{nr} increase in subsection 4.1. The first case is to make regular worker be cheaper and the second case is to make non-regular worker be more expensive. Since the firms in the model use CES production function, under imperfect substitution, those policies that affect relative prices have more interesting and realistic dynamics than them predicted by the model

[11] See `https://kosis.kr/statHtml/statHtml.do?orgId=118&tblId=DT_118N_SAUP50&conn_path=I3` (in Korean) for more details.

of the Cobb-Douglas production function. For example, if regular workers become relatively cheaper than non-regular workers, firms would like to hire regular workers more than ones predicted by the Cobb-Douglas production function economy as they are substitute. And I find the new stationary equilibrium if the government decreases the corporate tax τ. The government has implemented the tax deduction for firms to change non-regular workers to the regular workers. Intuitively, it lowers the marginal cost of regular and non-regular workers somewhat symmetrically. That is, the change of corporate tax would hardly change the relative price between regular employment and non-regular employment, thus firms would hire more non-regular workers as $W_r > W_{nr}$.[12]

Additionally, I evaluate again policy implications if $\rho = -0.5$, or equivalently $\sigma = 2/3$, when regular and non-regular workers are complements in the production function in subsection 4.2. If regular and non-regular workers are complements, the quantitative exercise implies that the fraction of regular workers is not changed much with respect to the exogenous change of social insurance payments or tax deduction. If the relative price of non-regular worker increases due to higher $s_n r$, the model when regular and non-regular workers are complements predicts that regular and non-regular workers decrease less than predictions by the benchmark model. At the same time, if the relative price of regular worker decreases due to lower s_r, the counter-factual model predicts that both workers increase less than predictions by the benchmark model. Furthermore, in subsection 4.3, I also implement the counter-factual study if firing cost of regular workers decreases as in Hopenhayn and Rogerson (1993).

4.1 Tax Credit & Social Security

Table 4 represents employments of regular and non-regular, the fraction of regular employment over aggregate employment, employment and output for each benchmark model and policy experiments. In Table 4, I consider six cases. In Policy 1, s_{nr} increases by 10%. And s_r decreases by 10% in Policy 2, all firms have tax deduction in Policy 3, firms who newly

[12]Note that this effect would be partially cancelled as the share of regular workers in the CES production function $\alpha > 0.5$.

hire regular workers only have tax deduction in Policy 4, Policy 1 and Policy 4 are jointly implemented in Policy 5 and Policy 2 and Policy 4 are jointly implemented in Policy 6. The relative price of non-regular employment increases in Policy 1 and The relative price of regular employment decreases in Policy 2.

If it becomes more expensive for hiring non-regular workers as in Policy 1, the fraction of regular employment increases but employment and output decrease substantially. The fraction of regular employment increases as the employment of non-regular decreases more than it of regular. Thus, average employment decreases but the loss of output is lower than employment as the share of non-regular workers $1-\alpha$ is small. Symmetrically, if the relative price of regular workers decrease as in Policy 2, the fraction of regular employment increases as the increment of it is greater than the increment of non-regular workers.

It is worthy to note that we would have different dynamics if we have different degree of elasticity of substitution. If ρ were smaller, that is, if the elasticity of substitution $\sigma = 1/(1-\rho)$ were smaller, the share of regular workers would be changed less. However, aggregate employment and thus aggregate output would decrease more in Policy 1.

The additional benefit of studying structural model is that it allows to consider the change of relative price more rigorously. In Policy 1 and Policy 2, the changes of relative employment for regular or non-regular workers with respect to the change of relative prices seems to be lower than implied σ. This is because the presence of adjustment costs makes the change of relative price smaller. This is hard to be considered in the reduced form analysis.

And the effect of corporate tax, τ is quantitatively smaller than the changes of relative prices in Policy 1 or Policy 2, as expected. This is intuitive as regular workers and non-regular workers are (imperfectly) substitute in the model.

4.2 Role of Substitution: Policy Experiments with Different ρ

Table 5 shows the results of policy experiments if $\rho = -0.5$. The goal of this exercise is to study the role of imperfect substitutes.

Policy Experiments: Benchmark model − if $\rho = 0.689$				
	Benchmark	Policy 1: $s_{nr} \uparrow$	Policy 2: $s_r \downarrow$	Policy 3: $\tau \downarrow$
Policy Changes				
	10.71%	10.71%	9.64 % (-10%)	10.71%
s_{nr}	10.71%	11.78% (+10%)	10.71%	10.71%
τ	16.00%	16.00%	16.00%	14.40% (-10%)
Employment and Output				
Regular Employment	6.2216	6.0842	6.4716	6.2475
Non-Regular Employment	1.2605	1.2192	1.2650	1.3405
Fraction of Regular Employment	0.8315	0.8331	0.8365	0.8233
Aggregate Employment	7.4821	7.3034	7.7366	7.5880
Aggregate Output	3.744	3.6800	3.8406	3.7730
Employment and Output: Changes Comparing to the Baseline Policy				
Regular Employment	1.0000	0.9914 (−0.86%)	1.0402 (+4.02%)	1.0042 (+0.42%)
Non-Regular Employment	1.0000	0.9683 (−3.17%)	1.0036 (+0.36%)	1.0635 (+6.35%)
Fraction of Regular Employment	1.0000	1.0040 (+0.40%)	1.0060 (+0.60%)	0.9901 (−0.99%)
Aggregate Employment	1.0000	0.9875 (−1.25%)	1.0340 (+3.40%)	1.0142 (+1.42%)
Aggregate Output	1.0000	0.9915 (−0.85%)	1.0258 (+2.58%)	1.0077 (+0.77%)

Table 4: Policy Experiment. s_r is the social security payment rate for regular workers, s_{nr} is the social security payment rate for non-regular workers and τ is the profit tax rate. s_{nr} increases by 10% in Policy 1, s_r decreases by 10% in Policy 2 and all firms have 10% corporate tax deduction in Policy 3.

Table 4 and Table 5 clearly show that the degree of substitution between regular and non-regular workers has crucial effects on inequalities and efficiency with respect to exogenous changes of policies. For example, while 10% increase of s_{nr} in the benchmark model ($\rho = 0.689$) decreases non-regular workers and regular workers by 3.17% and 0.86% respectively, it in the counter-factual model ($\rho = -0.500$) decreases non-regular workers and regular workers by 1.60% and 1.09% respectively. Thus, if regular and non-regular workers are substitutes, the exogenous shocks which affect relative prices would lead to more severe inequalities.

However, the output loss if they are complements would be worse than it if they are substitutes. Again, while while 10% increase of s_{nr} in the benchmark model decreases by 0.85%, it in the counter-factual model decreases by 0.87%. This is because while firms in the benchmark model reduce only non-regular workers as they are substitutes, firms in the counter-factual model reduce both regular and non-regular workers as they are complements. Similarly, if s_r decreases by 10%, inequalities in the benchmark model would become severe, as firms hire regular workers by 4.02% more but non-regular workers by 0.36% only. If they

	Policy Experiments for $\rho = -0.5000$			
	Benchmark	Policy 1: $s_{nr} \uparrow$	Policy 2: $s_r \downarrow$	Policy 3: $\tau \downarrow$
Policy Changes				
	10.71%	10.71%	9.64 % (-10%)	10.71%
s_{nr}	10.71%	11.78% (+10%)	10.71%	10.71%
τ	16.00%	16.00%	16.00%	14.40% (-10%)
Employment and Output				
Regular Employment	4.7724	4.7206	4.8750	4.7736
Non-Regular Employment	3.9608	3.8975	4.0251	4.0236
Fraction of Regular Employment	0.5465	0.5478	0.5478	0.5426
Aggregate Employment	8.7332	8.6180	8.9001	8.7972
Aggregate Output	3.6873	3.6552	3.7387	3.7002
Employment and Output: Changes Comparing to the Baseline Policy				
Regular Employment	1.0000	0.9891 (−1.09%)	1.0215 (+2.15%)	1.0018 (+0.18%)
Non-Regular Employment	1.0000	0.9840 (−1.60%)	1.0162 (+1.62%)	1.0089 (+0.89%)
Fraction of Regular Employment	1.0000	1.0024 (+0.24%)	1.0022 (+0.22%)	0.9967 (−0.33%)
Aggregate Employment	1.0000	0.9868 (−1.32%)	1.0191 (+1.91%)	1.0050 (+0.50%)
Aggregate Output	1.0000	0.9913 (−0.87%)	1.0135 (+1.35%)	1.0027 (+0.27%)

Table 5: Policy Experiments for $\rho = -0.5000$. s_r is the social security payment rate for regular workers, s_{nr} is the social security payment rate for non-regular workers and τ is the profit tax rate. s_{nr} increases by 10% in Policy 1, s_r decreases by 10% in Policy 2 and all firms have 10% corporate tax deduction in Policy 3.

are complements, as shown in Table 5, firms hire regular workers by 2.15% and non-regular workers by 1.62%. However, given the share of regular workers $\alpha > 0.5$ in the CES production, it implies that output efficiency is greater in the benchmark model.[13]

4.3 Firing Costs

Table 6 shows the results of policy experiments with counter-factual study − lower firing cost c_-. c_- decreases 10% in Policy 2-1, c_- decreases by 10% and s_{nr} increases by 10% in Policy 2-2, c_- decreases by 10% and s_r decreases by 10% in Policy 2-3, c_- decreases by 10% and τ decreases by 10% for all firms in Policy 2-4, c_- decreases by 10% and τ decreases by 10% for firms who newly hire regular workers only in Policy 2-4, Policy 2-5 and 10% decrease of s_r are jointly implemented in Policy 2-6 and Policy 2-5 and 10% increase of s_{nr} are jointly implemented in Policy 2-7.

[13]Intuition here is similar with Jang and Yum (2022).

Policy Experiment 2: Tax, Social Security and Firing Cost								
	Benchmark	Policy 2-1: $c_- \downarrow$	Policy 2-2: $c_- \downarrow$ & $s_{nr} \uparrow$	Policy 2-3: $c_- \downarrow$ & $s_r \downarrow$	Policy 2-4: $c_- \downarrow$ & $\tau \downarrow$ unconditionally	Policy 2-5: $c_- \downarrow$ & $\tau \downarrow$ conditionally	Policy 2-6: Policy 2-5 + $s_{nr} \uparrow$	Policy 2-7: Policy 2-5 + $s_r \downarrow$
Policy Changes								
c_-	1.0137	0.9123	0.9123	0.9123	0.9123	0.9123	0.9123	0.9123
s_r	10.71%	10.71%	10.71%	9.64%	10.71%	10.71%	10.71%	9.64%
s_{nr}	10.71%	10.71%	11.78%	10.71%	10.71%	10.71%	11.78%	10.71%
τ	16.00%	16.00%	16.00%	16.00%	14.40%	14.40%	14.40%	14.40%
Employment and Output								
Regular Employment	6.2216	6.7058	6.7213	6.7688	6.7427	6.6392	6.5815	6.7051
Non-Regular Employment	1.2605	1.2699	1.2311	1.2714	1.3507	1.3144	1.2739	1.3159
Fraction of Regular Employment	0.8315	0.8408	0.8452	0.8419	0.8331	0.8347	0.8378	0.8359
Aggregate Employment	7.4821	7.9757	7.9523	8.0402	8.0934	7.9536	7.8554	8.0209
Aggregate Output	3.744	3.9351	3.9309	3.9627	3.9689	3.9195	3.8892	3.9487
Employment and Output: Changes Comparing to the Benchmark Model								
Regular Employment	1.0000	1.0778	1.0803	1.088	1.0838	1.0671	1.0578	1.0777
Non-Regular Employment	1.0000	1.0075	0.9767	1.0086	1.0716	1.0428	1.0106	1.044
Fraction of Regular Employment	1.0000	1.0112	1.0165	1.0125	1.0019	1.0038	1.0076	1.0053
Aggregate Employment	1.0000	1.066	1.0628	1.0746	1.0817	1.063	1.0499	1.072
Aggregate Output	1.0000	1.051	1.0499	1.0584	1.0601	1.0469	1.0388	1.0547

Table 6: Policy Experiment 2. c_- is the adjustment cost when the firm fires regular workers which is the portion of wages, s_r is the social security payment rate for regular workers, s_{nr} is the social security payment rate for non-regular workers and τ is the profit tax rate. c_- decreases 10% in Policy 2-1, c_- decreases by 10% and s_{nr} increases by 10% in Policy 2-2, c_- decreases by 10% and s_r decreases by 10% in Policy 2-3, c_- decreases by 10% and τ decreases by 10% for all firms in Policy 2-4, c_- decreases by 10% and τ decreases by 10% for firms who newly hire regular workers only in Policy 2-4, Policy 2-5 and 10% decrease of s_r are jointly implemented in Policy 2-6 and Policy 2-5 and 10% increase of s_{nr} are jointly implemented in Policy 2-7.

5 Conclusion

This paper studies the elasticity of substitution between regular and non-regular workers in both perspectives of empirical estimate and policy experiments using the structural model to evaluate policies which affect the relative price between them. To my best knowledge, it is the first study to explore the degree of imperfect substitution between regular and non-regular workers for both perspectives of reduced-form analysis and structural model analysis.

I show that the empirical estimate of the elasticity of substitution is greater than unity, which implies that regular and non-regular workers are (imperfectly) substitutes. Using the empirical estimate, I calibrate the structural heterogeneous firm model to implement policy experiments which is hard to investigate quantitatively in the reduced-form analysis. The quantitative policy experiments imply that it is crucial to consider the degree of imperfect substitutes. I show that while there would be more inequalities if regular and non-regular workers are substitutes, the output losses (gains) would be less (more) with respect to exogenous policy shocks than if they are complements.

References

Ackerberg, Daniel A., Kevin Caves, and Garth Frazer, "Identification Properties of Recent Production Function Estimators," *Econometrica*, 2015, *83* (6), 2411–2451.

Chang, Yongsung, Taesu Kang, and Sun-Bin Kim, "The impacts of Dual Labour Markets on Unemployment and Productivity," *BOK Working Paper*, 2016, *22* (1), 1–34.

Elsby, Michael W. L. and Ryan Michaels, "Marginal Jobs, Heterogeneous Firms, and Unemployment Flows," *American Economic Journal: Macroeconomics*, January 2013, *5* (1), 1–48.

_ , _ , and David Ratner, "The aggregate effects of labor market frictions," *Quantitative Economics*, 2019, *10* (3), 803–852.

Hopenhayn, Hugo and Richard Rogerson, "Job Turnover and Policy Evaluation: A General Equilibrium Analysis," *Journal of Political Economy*, 1993, *101* (5), 915–938.

Jang, Youngsoo and Minchul Yum, "Aggregate and Intergenerational Implications of School Closures: A Quantitative Assessment," *Working Paper*, 2022.

Kim, Yoo-Bin, Hyeongjun Bang, and Chung Choe, "Analysis on the Effect of Hiring Non-Regular Workers for Firm's Productivity in Short-Run and Long-Run," *Korea Labor Institute and Ministry of Employment and Labor*, 2020.

_ , Jung-Woo Kim, Minsu Song, and Ki-Min Kim, "Report on 1-6th wave Workplace Panel Survey," *Korea Labor Institute*, 2018.

_ , ShinHyuck Kang, Dohyung Kim, Jiwoon Kim, Seokjin Woo, Koangsung Choi, and Chung Choe, "Effect of Employment Maintenance Subsidy Policy during Covid-19 Crisis," *Korea Labor Institute and Ministry of Employment and Labor*, 2021.

Kmenta, J., "On Estimation of the CES Production Function," *International Economic Review*, 1967, *8* (2), 180–189.

Krusell, Per, Lee E. Ohanian, José-Víctor Ríos-Rull, and Giovanni L. Violante, "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, 2000, *68* (5), 1029–1053.

Lucas, Robert E., "On the Size Distribution of Business Firms," *The Bell Journal of Economics*, 1978, *9* (2), 508–523.

Miyamoto, Hiroaki, "Growth and non-regular employment," *The B.E. Journal of Macroeconomics*, 2016, *16* (2), 523–554.

Descriptive Statistics: Workplace Panel Survey (WPS)					
	Mean	Standard Deviation	Minimum	Maximum	Number of Samples
Total Employment	211.30	623.07	11	14,451	1,486
Regular Employment	139.64	348.05	2	8,687	1,486
Non-Regular Employment	71.66	428.75	1	12,634	1,486
Revenue (Real, million won)	158,896.20	928,431.30	274	34,800,000	1,191
Capital (Real, million won)	53,690.64	302,371.70	0	9,055,096	1,191
COGS (Real, million won)	112,635.40	735,369.50	0	21,800,000	1,150
SG&A (Real, million won)	26,186.38	121,676.90	0	1,173,039	1,197
Workplace Age	25.98	14.72	2	115	1,486

Table 7: Descriptive Statistics of WPS if there is no restriction on financial variables but restriction on regular and non-regular employment. All statistics computed using the sample weights provided by the WPS.

Appendices

A Descriptive Statistics: WPS

Table 7 represents the descriptive statistics of WPS if there is restriction on the number of regular and non-regular employment (that is, each workplace should have the positive number of employees for both regular and non-regular) but no restriction on the financial variables.