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

ShinHyuck Kang†
Chonnam National University

September 3, 2026

Abstract

This paper estimates the substitutability of regular and non-regular workers in South Korea and quantifies employer-side contribution-rate counterfactuals. Using establishment-level Workplace Panel Survey data, I estimate the relative input-demand equation implied by a CES labor aggregate. The preferred point estimate, $\hat{\rho} = 0.3100$, implies an elasticity of substitution of $\hat{\sigma} = 1.4493$ under the maintained static CES interpretation. I impose this FOC-based estimate as an external empirical discipline in a calibrated heterogeneous-firm model with dynamic regular employment, flexible non-regular employment, endogenous wages, and adjustment costs for regular jobs. A 10 percent proportional increase in the non-regular contribution rate reduces non-regular employment by 1.86 percent, total employment by 0.29 percent, and output by 0.18 percent. A 10 percent proportional reduction in the regular contribution rate raises total employment by 0.45 percent and output by 0.27 percent. The counterfactuals allow substitution, wage adjustment, and regular-employment frictions to operate jointly.
JEL Classification: E20, E60, J30
Keywords: Dual labor market, Imperfect substitution, Policy experiments

*This paper is a revised version of the policy report "The analysis of the effects of tax and social insurance system on the selection of employment type" (with Jongsuk Ahn, MinKi Hong, and MoonJung Kim), requested and financially supported by the Ministry of Employment and Labor in South Korea.

†Chonnam National University, Email: shinkang@jnu.ac.kr. I am grateful to Jongsuk Ahn, Jooyeop Ahn, Yoosoon Chang, Joonkyu Choi, Yunjong Eo, MinKi Hong, Heechul Jung, Jinyoung Kim (Korea University), Kyungbae Kim, MoonJung Kim, Seongeun Kim, Changsu Ko, Jong-Eun Lee, Tae-Hwan Lee, Hyun-Joon Lim, Joonseok Oh, Serena Rhee, Kwanho Shin, Wonmun Shin, Chunzan Wu, and Sangjun Yea for valuable comments. I also thank seminar participants at Sejong University, the 16th International Symposium on Econometric Theory and Applications (SETA) 2022, Myongji University, Yonsei Junior Macro Group, Korea University, the Bank of Korea, and the Korean Association of Public Finance. The views expressed are my own; all errors are mine.

1 Introduction

Labor market duality remains a central policy challenge in South Korea. Non-regular workers generally earn less and face weaker employment security than regular workers. Many policies intended to address these disparities operate by changing employers' effective costs of the two employment categories. For example, raising the employer-side social-insurance contribution rate for non-regular workers increases their labor cost relative to that of regular workers, whereas reducing the corresponding rate for regular workers works in the opposite direction. The employment and aggregate effects of such policies therefore depend on how readily firms substitute between regular and non-regular labor. Despite its importance for policy evaluation, this margin has received relatively little quantitative attention.

This paper addresses two questions. First, how readily can firms substitute between regular and non-regular workers at the establishment level? Second, how do employer-side contribution-rate changes affect employment composition and aggregate outcomes once substitution, wage adjustment, and regular-employment adjustment costs are taken into account? To answer the first question, I estimate the relative input-demand equation implied by the first-order condition of a CES labor aggregate. Under the maintained static CES cost-minimization interpretation, the coefficient provides an FOC-implied medium-run substitution parameter. An AKP-style production-side exercise then estimates the auxiliary labor exponent conditional on this curvature and assesses the strength of production-side identification. The empirical and structural exercises play distinct roles: the calibrated heterogeneous-firm model does not re-estimate the labor-nest curvature, but imposes the FOC-based estimate as an external empirical discipline and quantifies how employer-side cost changes propagate through dynamic regular employment, flexible non-regular employment, endogenous wages, labor-market tightness, and hiring and firing costs for regular jobs.

The main empirical finding is an FOC-implied curvature of $\hat{\rho}^{FOC} = 0.3100$, corresponding to an elasticity of substitution of $\hat{\sigma} = 1.4493$. In the estimated relative input-demand equation, a 1% increase in the labor cost of non-regular workers relative to that of regular workers is associated with an approximately 1.45% increase in the ratio of regular to non-regular employment. The point estimate therefore implies imperfect substitution. The 95 percent confidence interval, however, includes the Cobb–Douglas case and slightly negative values of ρ. The point estimates remain positive and within a moderate range across alternative control sets, while leave-one-out relative labor-cost estimates are positive but imprecise. The production-side profile is boundary-seeking and does not deliver a credible interior estimate of ρ; the structural model therefore uses the relative-demand estimate as a medium-run external discipline for the labor nest rather than as a direct estimate of every dynamic margin in the model.

The stationary-equilibrium counterfactuals show that employer-side contribution changes affect employment composition and aggregate outcomes through both substitution and equilibrium adjustment. Under the empirical value of ρ, a 10% proportional increase in the employer-side social-insurance rate for non-regular workers reduces non-regular employment by 1.86%, total employment by 0.29%, and output by 0.18%, while leaving regular employment nearly unchanged. A 10% proportional reduction in the corresponding rate for regular workers raises regular employment by 0.51%, non-regular employment by 0.12%, total employment by 0.45%, and output by 0.27%, while reducing the non-regular employment share. These responses are not mechanical applications of the CES elasticity because wages, labor-market tightness, and the dynamic regular-employment margin also adjust. The exercises isolate the employer-cost channel and are not welfare evaluations of alternative social-insurance systems.

The paper also reports an illustrative complementarity stress test with $\rho = -0.1000$, a value below the lower bound of the pooled 95 percent confidence interval. In the non-regular contribution experiment, the alternative complementarity calibration produces a smaller decline in the non-regular employment share and a slightly smaller output loss, but a larger decline in the regular wage premium. In the regular contribution experiment, the decline in the non-regular employment share is again smaller, whereas the total-employment and output gains are somewhat larger. Because this calibration also changes the CES weight, regular-task efficiency, and productivity scale, the comparison is not a ceteris-paribus estimate of the effect of ρ. Instead, it illustrates how policy transmission varies across alternative wage, productivity, and substitution environments.

The paper contributes to the literature in three ways. First, it provides establishment-level panel evidence on the FOC-implied substitutability of regular and non-regular labor in South Korea. Second, it embeds the empirically disciplined labor nest in a heterogeneous-firm model in which regular employment is a dynamic decision and non-regular employment is a flexible within-period margin. Third, it compares the relative labor-cost movement inferred from an aggregate static CES calculation with the relative-cost response generated by the calibrated model, documenting when the two accounting exercises align and when equilibrium adjustment creates a gap.

Related Literature In the literature on regular and non-regular employment, Miyamoto (2016) develops a structural macro model with search frictions to study how productivity growth affects the share of non-regular employment. Chang et al. (2016) analyzes Korean labor-market duality in a Diamond–Mortensen–Pissarides framework. Relative to these studies, this paper places the substitution margin between regular and non-regular labor at the center of the quantitative exercise and estimates its FOC-implied value using establishment-level panel data.

The paper also relates to the macroeconomic literature on imperfect substitution across production inputs. Krusell et al. (2000) estimate capital–skill complementarity using simulated pseudo-maximum likelihood. Dolado et al. (2021) study capital–skill complementarity in a New Keynesian model, and Ohanian et al. (2023) revisit the same margin using more recent data. Whereas that literature focuses mainly on capital and skill groups, this paper studies imperfect substitution between two employment categories within establishments.

Finally, the empirical strategy is connected to the literature on CES production estimation. Kmenta (1967) proposes a first-order Taylor approximation to the CES production function, while later work emphasizes the limitations of linear approximations when the elasticity is not close to the Cobb–Douglas case (Koesler and Schymura, 2015). Applied macro studies such as An et al. (2019a) and Chang and Lee (2023) estimate substitution elasticities between public and private capital. This paper uses the CES relative first-order condition to estimate the labor-nest curvature and an AKP-style production-side exercise (An et al., 2019b) to discipline the auxiliary labor exponent and assess production-side identification.

The remainder of the paper is organized as follows. Section 2 describes the institutional background and the measurement of regular and non-regular employment. Section 3 presents the empirical analysis. Section 4 introduces the structural model and policy experiments. Section 5 concludes.

2 Institutional Background and Measurement

2.1 Regular and Non-regular Employment in South Korea

The distinction between regular and non-regular employment in Korea is broader than a distinction between permanent and temporary contracts. Regular employment generally denotes a standard direct employment relationship, whereas non-regular employment is an umbrella category defined by contract duration, working hours, or the form of the employment relationship. It includes fixed-term and other contingent workers, part-time workers, and atypical arrangements such as agency-dispatched or subcontracted work. These categories can overlap, and some directly employed non-regular workers hold indefinite-term contracts. This paper therefore treats non-regular employment as a composite labor input rather than as a single legal contract type (Statistics Korea, 2019; Kim et al., 2018, 2020).

The two employment categories also differ in the expected cost and timing of workforce adjustment. Regular jobs tend to be more persistent, and adjusting them can involve recruitment and training costs, procedural requirements, severance obligations, and potential dispute costs. Fixed-term and indirect arrangements can often be adjusted more quickly through contract expiration, changes in hours, or changes in outsourcing demand. This distinction is relative rather than absolute: non-regular labor is not costless to adjust, and regular employment is not immutable. OECD assessments link efforts to reduce Korean labor-market duality with both a rebalancing of employment protection and broader social-insurance enrollment (OECD, 2024). These institutional differences motivate the structural model's treatment of regular employment as a dynamic choice subject to hiring and firing costs and non-regular employment as a relatively flexible within-period margin.

2.2 Measurement in the Workplace Panel Survey

The empirical analysis uses the Workplace Panel Survey (WPS), a government-approved establishment-level panel conducted by the Korea Labor Institute (Kim et al., 2018, 2020). The WPS follows workplaces with 30 or more employees and reports employment by category together with workplace characteristics and financial variables. Its establishment-level structure is well suited to studying how production units adjust the composition of regular and non-regular labor. The baseline relative-demand sample is further restricted to establishments that employ both labor categories and report the relative-wage information. The resulting estimate should therefore be interpreted as an intensive-margin relationship for dual-user establishments, not as an economy-wide extensive-margin response or as representative of very small workplaces.

The employment measures follow the WPS questionnaire. From 2015 onward, regular employment is reported directly, while non-regular employment is measured as the sum of directly employed non-regular workers and indirectly employed workers. For earlier waves, the paper constructs non-regular employment from the available fixed-term, part-time, subcontracted, work-at-home, foreign, and other categories, and obtains regular employment from total employment net of these categories. The baseline relative-demand estimation uses the

2015, 2017, and 2019 waves because the relative-wage questions are available only in those waves; the production-side exercise can use a longer sample. Because indirect workers are included, the variable is best understood as non-regular labor services used at the establishment rather than only workers on its own payroll. The resulting establishment-level shares are not directly comparable with national worker-level statistics because the unit of observation, workplace-size coverage, sample restrictions, and treatment of indirect employment differ.

The WPS reports wages for several non-regular groups relative to regular workers, whose wage is normalized to 100. The paper combines the reported relative wages for indefinite-term contract, fixed-term, part-time, and subcontracted or service workers using employment weights. To align the coverage of the wage and employment measures, the baseline proxy assigns the subcontracted or service-worker wage to the broader indirect-employment category. For indirect workers, however, the reported wage need not equal the full service price paid by the user establishment. The variable is therefore interpreted as a survey-based proxy that co-moves with the relative unit cost of non-regular labor services, rather than as a complete compensation or outsourcing bill. This maintained measurement assumption is assessed using alternative proxy definitions in the empirical robustness exercises.

2.3 Employer-side Social Insurance and the Policy Wedge

Employer-side social-insurance contributions enter effective labor costs in addition to wages. In the baseline empirical specification, contribution factors are set symmetrically across regular and non-regular labor, so the identifying variation in relative labor costs comes primarily from establishment-level relative wages. The structural benchmark likewise starts from a common employer-side contribution rate and then changes the contribution factor for one labor category in the policy counterfactuals.

These experiments should be interpreted as stylized changes in the effective employer-side labor-cost wedge, not as a claim that the current statutory system assigns different contribution rates solely according to employment status. Such a wedge can represent a targeted subsidy or rebate, a surcharge, or a change in effective enrollment or enforcement. For directly employed non-regular workers, it changes payroll costs directly. For indirect labor services, the benchmark assumes that the contribution change is passed through to the unit service cost faced by the user establishment. The model abstracts from the underlying contracting chain and represents both channels as a change in the effective unit cost of the composite non-regular input. A 10 percent policy change denotes a proportional change in the existing contribution rate, not a 10 percentage-point change.

The counterfactuals isolate the employer-cost channel. They do not value the insurance benefits received by workers, impose a government budget constraint, model labor-force participation, or provide a welfare ranking of alternative social-insurance systems. Within this scope, the institutional and measurement choices define the mapping from the Korean setting to the analysis. The empirical section treats regular and non-regular labor as distinct composite inputs and estimates their FOC-implied substitutability from within-establishment changes in measured relative labor costs. The structural model treats each establishment as an independent production unit, makes regular employment a dynamic margin with hiring and firing costs, treats non-regular labor as a relatively flexible current-period margin, and represents employer-side contribution changes as changes in the relative-cost wedge between the two inputs.

3 Empirical Analysis

This section estimates the labor-nest parameter used in the structural model. The empirical object is the substitutability of regular and non-regular workers. The institutional definitions of the two employment categories are given above. Here, the focus is the estimation sample, financial controls, and construction of the relative labor-cost proxy. The preferred estimate comes from the relative input-demand equation implied by the first-order condition of a CES labor aggregator. An AKP-style production-side exercise in the spirit of An et al. (2019b) is used as a diagnostic and as support for the auxiliary labor-scale parameter in the structural calibration.

3.1 Estimation Method and Identification

Let regular employment be R_{it} and non-regular employment be I_{it}. The empirical analysis is organized around the following CES labor aggregate:

$$L_{it} = \left[\alpha R_{it}^{\rho} + (1-\alpha) I_{it}^{\rho}\right]^{1/\rho}. \tag{1}$$

The elasticity of substitution between regular and non-regular workers is

$$\sigma = \frac{1}{1-\rho}. \tag{2}$$

Thus, $\rho > 0$ implies $\sigma > 1$, while $\rho < 0$ implies $\sigma < 1$. The parameter ρ is the main empirical input for the structural model because it governs substitution between the two employment types when relative labor costs change.

A natural approach would be to estimate the full production function,

$$Y_{it} = A_{it} K_{it}^{1-\gamma_L} \left[\alpha R_{it}^{\rho} + (1-\alpha) I_{it}^{\rho}\right]^{\gamma_L/\rho}. \tag{3}$$

Estimating ρ, α, and the auxiliary labor exponent γ_L jointly from the production side is difficult in this setting. In the logarithm of Equation 3, γ_L and ρ enter nonlinearly through γ_L/ρ and the CES composite. With a short establishment panel, measurement error in employment and financial variables, and unobserved productivity shocks, the production-side objective can be flat in ρ and may move toward boundary values. I therefore separate the two exercises. The FOC equation provides the baseline estimate of labor-nest curvature. The production-side exercise is used as a diagnostic and to discipline an auxiliary labor-scale parameter conditional on that curvature.

The preferred specification uses the cost-minimization first-order condition implied by Equation 1. Let $C_{R,it}$ and $C_{I,it}$ denote firm-level unit labor costs for regular and non-regular workers. The relative demand equation is

$$\log\left(\frac{R_{it}}{I_{it}}\right) = \kappa + \sigma \log\left(\frac{C_{I,it}}{C_{R,it}}\right) + X_{it}'\beta + \mu_i + \lambda_t + \varepsilon_{it}. \tag{4}$$

The auxiliary production-scale parameter γ_L does not enter the relative first-order condition. Under the maintained static CES cost-minimization interpretation, the coefficient on relative non-regular labor cost equals the substitution elasticity σ, and the corresponding FOC-implied curvature is $\rho^{FOC} = 1 - 1/\sigma$. Identification comes from within-establishment changes in relative labor costs after absorbing persistent establishment heterogeneity and common time shocks. Because regular employment may adjust gradually, I use $\hat{\rho}^{FOC}$ as a medium-run external empirical discipline for the labor nest rather than as a separately estimated technological curvature of the dynamic model.

The baseline specification includes establishment fixed effects and year fixed effects. Establishment fixed effects absorb persistent differences in productivity, human-resource practices, and workforce composition. Year fixed effects absorb aggregate shocks and common policy changes. The controls X_{it} include real capital, real cost of goods sold (COGS), real selling, general, and administrative expenses (SG&A), establishment age, and establishment age squared. Because COGS and SG&A may themselves be related to production choices, alternative control sets are reported, while the COGS+SG&A specification is used as the benchmark carried into the structural calibration.

The main remaining endogeneity concern is that establishment-level relative wages may respond to contemporaneous establishment-specific labor demand shocks. To reduce the role of own-establishment wage responses, I construct leave-one-out relative labor-cost measures using other establishments in the same industry-year or industry-region-year cell. These estimates remain positive in the preferred industry-region-year specifications, although they are less precise than the baseline estimates.[1] The baseline FOC specification remains the main source of identification and the main input for the structural calibration.

An AKP-style production-side exercise An et al. (2019b) disciplines parameters other than the main substitution parameter. The exercise profiles the CES-CD production equation over fixed values of ρ and α, and then estimates the auxiliary labor exponent γ_L in a level fixed-effects specification. The production-side profile still prefers values of ρ close to the perfect-substitution boundary, so I interpret it as evidence that production variation alone does not deliver a reliable interior estimate of ρ. Conditional on the FOC estimate of ρ, the production-side exercise provides information about the scale of the labor aggregate used in the structural model.

3.2 Workplace Panel Survey Data

The WPS is a government-approved establishment-level panel survey conducted by the Korea Labor Institute. The WPS 2005 sample has been followed in biennial waves and contains detailed information on employment, workplace characteristics, and financial variables through 2019. The survey reports regular and non-regular employment together with establishment-level financial information. Its main limitation is that it covers workplaces with 30 or more employees, so the estimates apply to establishments large enough to have an internal margin between regular and non-regular employment.

The construction of regular and non-regular employment follows the WPS questionnaire structure. From 2015 onward, regular employment is directly reported in the WPS, while non-regular employment is measured as the sum of directly employed non-regular workers and indirectly employed workers. For earlier waves, non-regular employment is constructed from fixed-term workers, part-time workers, foreign workers, employment from subcontractors,

[1]Policy-exposure IV specifications based on pre-period reliance on non-regular workers interacted with post-2015 waves point in the same broad direction, but the first stage is weak. They are therefore used only as diagnostic evidence.

work-at-home workers, and other employees. The corresponding pre-2015 measure of regular employment is constructed from total employment net of non-regular categories. The baseline FOC estimation uses the 2015-2019 sample because the relative wage questions used to construct $C_{I,it}/C_{R,it}$ are available only from 2015 onward. The production-side AKP-style exercise uses a longer sample when relative wage information is not required. Detailed definitions of the WPS employment variables are described in Kim et al. (2018, 2020).

Financial variables enter both the control set and the production-side exercise. Revenue is measured as the average of current and lagged sales. Capital is measured by property, plant, and equipment. COGS and SG&A control for time-varying cost and scale conditions. All nominal financial variables are converted into real values using the CPI, with 2015 as the base year. Observations with non-positive sales are excluded from the empirical sample, while COGS and SG&A enter only in the specifications that use them as controls. Observations for which regular plus non-regular employment exceeds total employment are dropped, and positive regular and non-regular employment is required in the baseline relative-demand sample. Table 10 reports the resulting sample construction, and Table 11 reports summary statistics for the benchmark FOC sample.

The establishment-level relative labor-cost proxy is a key empirical input. From 2015 onward, the WPS asks establishments to report the wage level of several types of non-regular workers relative to regular workers, whose wage is normalized to 100. I use four relative wage questions: indefinite-term contract workers, fixed-term workers, part-time workers, and subcontracted or service workers. Since the WPS reports type-specific relative wages rather than a complete establishment-level wage bill by employment category, the proxy may also reflect the composition of non-regular employment. For indirectly employed workers, the proxy is a wage measure rather than the full contractor service price. I therefore interpret it as moving with the establishment's relative unit labor cost. Alternative proxy diagnostics and robustness estimates are reported in Table 12 and Table 13. The baseline measure is the employment-weighted non-regular relative wage:

$$\frac{\widetilde{w}_{it}^{I}}{w_{it}^{R}} = \sum_{g} \omega_{git} \frac{\widetilde{w}_{it}^{g}}{w_{it}^{R}}, \tag{5}$$

where g indexes non-regular worker types and ω_{git} is the corresponding employment weight. The baseline proxy assigns the subcontract/service relative wage to the full indirect-employment category so that the coverage of the wage proxy is aligned as closely as possible with the non-regular employment measure. In robustness work, I also consider narrower versions that use only directly employed non-regular workers or directly measured subcontract/service employment.

The relative labor-cost proxy is

$$\frac{C_{I,it}}{C_{R,it}} = \frac{\widetilde{w}_{it}^{I}}{w_{it}^{R}} \times \frac{1+\tau_{I,t}^{f}}{1+\tau_{R,t}^{f}}, \tag{6}$$

where $\tau_{g,t}^{f}$ is the employer-side payroll contribution rate for employment type g. In the baseline empirical specification, the gross payroll-cost factors are set symmetrically across regular and non-regular workers. Thus the identifying variation in $\log(C_{I,it}/C_{R,it})$ is primarily the establishment-level relative wage variation. In the structural model, by contrast, social-insurance rates are explicitly changed by employment type to generate counterfactual relative labor-cost variation.

3.3 Estimation Results

Table 1 reports estimates of Equation 4 under alternative control sets. The regression coefficient estimates σ. For compact presentation, the table reports the CES curvature parameter $\rho = 1 - 1/\sigma$ with delta-method standard errors, while σ is reported as the implied value. Across specifications, the point estimates imply positive substitutability between regular and non-regular workers. The benchmark specification controls for COGS and SG&A, in

FOC Estimates of Regular/Non-Regular Substitution				
	(1) Core	(2) COGS only	(3) SG&A only	(4) COGS+SG&A
$\hat{\rho}$	0.1584	0.3515**	0.2931*	0.3100*
	(0.2558)	(0.1475)	(0.1741)	(0.1674)
Implied $\hat{\sigma} = 1/(1-\hat{\rho})$	1.1882	1.5421	1.4145	1.4493
Observations	2,613	2,534	2,594	2,527
Establishments	1,517	1,491	1,511	1,489
Establishment FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Capital, age controls	Yes	Yes	Yes	Yes
COGS control	No	Yes	No	Yes
SG&A control	No	No	Yes	Yes

Notes: The dependent variable is $\log(R_{it}/I_{it})$. Under the maintained static CES interpretation, the FOC coefficient estimates σ; the table reports $\rho = 1 - 1/\sigma$. Standard errors for ρ, clustered at the establishment level, are computed by the delta method and reported in parentheses. Stars test $\rho = 0$. Values are rounded to four decimal places. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1: Baseline relative input-demand estimates using WPS.

addition to capital, establishment age, establishment age squared, establishment fixed effects, and year fixed effects. This richest-control specification absorbs production-cost and overhead-cost conditions that may be correlated with the establishment's employment mix.

The preferred estimate is the COGS+SG&A specification in column (4). This point estimate implies $\hat{\rho}^{FOC} = 0.3100$ and $\hat{\sigma} = 1.4493$, so regular and non-regular workers are substitutes but far from perfect substitutes. This value is imposed as an external empirical discipline in the structural model. The confidence interval for the benchmark estimate is wide and reaches values close to zero. The $\rho = -0.1000$ case used below lies below the lower bound of the pooled 95 percent confidence interval. It is therefore interpreted only as an illustrative complementarity stress test, not as a second empirical estimate.

Table 2 reports the production-side exercise used to discipline the auxiliary labor exponent γ_L. In all columns, ρ is fixed at the benchmark FOC value and $\alpha = 0.7000$ is used in the CES labor composite. The estimated γ_L is below one across specifications. The COGS+SG&A specification gives $\hat{\gamma}_L = 0.6976$. Because the structural model abstracts from capital, I use this estimate as an external numerical discipline and set the labor-block curvature to $\nu = 0.6976$. This mapping is a calibration convention rather than an identity implied by the auxiliary production function. The structural calibration later uses $\alpha = 0.7500$,

AKP-style Level-FE CES Production Estimates				
	(1) Core	(2) COGS only	(3) SG&A only	(4) COGS + SG&A
$\hat{\gamma}_L$	0.5385***	0.5543***	0.6846***	0.6976***
	(0.0447)	(0.0409)	(0.0404)	(0.0377)
Fixed ρ	0.3100	0.3100	0.3100	0.3100
Fixed α	0.7000	0.7000	0.7000	0.7000
Within R^2	0.4740	0.5081	0.6275	0.6522
Observations	4,375	4,205	4,334	4,179
Establishments	2,182	2,129	2,175	2,125
Establishment FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
COGS control	No	Yes	No	Yes
SG&A control	No	No	Yes	Yes

Notes: The dependent variable is $\log Y_{it} - \log K_{it}$. The regressor is $\log L_{it}^{CES} - \log K_{it}$, so γ_L is the labor exponent in the auxiliary CES-CD production equation. Standard errors clustered at the establishment level are reported in parentheses. Values are rounded to four decimal places. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Production-side calibration support conditional on the FOC estimate of ρ.

slightly above the empirical profile value, jointly with χ_R to discipline the wage premium and employment composition.

The production-side profile is informative, but it is not used as the main identification source for ρ. Table 15 shows that the COGS+SG&A profile is minimized near $\rho = 0.9900$, close to the perfect-substitution boundary. Moving from this boundary value to the FOC estimate raises the residual sum of squares by 4.9707 percent and lowers the within R^2 from 0.6687 to 0.6522. This pattern indicates that production-side variation alone is not sharp enough to discipline the labor-nest curvature in the WPS. It remains useful for the auxiliary labor exponent γ_L conditional on the FOC estimate of ρ.

3.4 Heterogeneity and Robustness

The baseline estimate should be interpreted as an average effect across establishments that employ both regular and non-regular workers. As a heterogeneity check, the same FOC equation is estimated separately by broad industry group. Table 16 shows stronger substitutability in manufacturing. The estimates for services and other industries are lower and less precise. Formal interaction tests are consistent with this pattern: equality of slopes across manufacturing, services, and other industries is rejected at the 10 percent level, with $p = 0.0546$, while the difference between services and other industries is not statistically meaningful, with $p = 0.7125$.

The heterogeneity results are treated as external-validity evidence rather than as alternative calibration targets. The structural model therefore uses the average FOC estimate in Table 1. The proxy robustness estimates in Table 13 show that coverage-equivalent definitions remain close to the baseline and that winsorizing the baseline proxy produces a slightly larger point estimate. The direct-employment-only proxy uses a narrower worker set that is not coverage-equivalent to the baseline non-regular input; it yields a negative but highly imprecise point estimate. The preferred industry-region-year leave-one-out specifications in Table 14 remain positive, although they are imprecise. The empirical section therefore provides a moderate FOC-implied substitution estimate for the labor nest, shows that production-side data alone weakly discipline ρ, and supplies the external empirical inputs used to calibrate the structural model.

4 Structural Model

The empirical labor-nest estimate is embedded in a heterogeneous-firm model with dynamic regular employment, flexible non-regular employment, endogenous wages, and equilibrium labor-market tightness. The model does not re-estimate the elasticity of substitution. The benchmark calibration imposes $\rho^{model} = \hat{\rho}^{FOC} = 0.3100$ and uses the model to quantify how employer-side cost changes propagate through wages, regular-employment adjustment, and labor-market tightness. The FOC estimate summarizes an intensive-margin response among establishments using both labor inputs. Employer-side contribution-rate changes also affect wages, regular hiring and separation decisions, and aggregate output.[2]

The model builds on the heterogeneous-firm tradition with labor adjustment frictions, as in Hopenhayn and Rogerson (1993), and uses a tractable search-and-bargaining block in the spirit of Elsby and Michaels (2013); Elsby et al. (2019). Regular jobs are costly to adjust, while non-regular jobs are chosen as a within-period flexible margin. This asymmetry is the main institutional feature of the model. Policies that raise the cost of non-regular labor do not simply move employment along a static CES demand curve, because firms also account for the option value and adjustment cost of regular employment.

4.1 Model Environment

Time is discrete and the model period is monthly. A firm is characterized by idiosyncratic productivity x_t and previous-period regular employment R_{t-1}. In each period the firm chooses current regular employment R_t. Conditional on R_t and x_t, it chooses non-regular employment I_t from a static first-order condition. Regular employment is a dynamic state-dependent margin, whereas non-regular employment is a flexible within-period margin. The variable I_t is a composite of non-regular labor services used by the establishment, including directly employed non-regular workers and indirect labor services in the empirical measure.

Productivity follows a first-order Markov process,

$$\log x_{t+1} = \rho_x \log x_t + \varepsilon_{t+1}, \qquad \varepsilon_{t+1} \sim iid\mathcal{N}(0, \sigma_x^2). \tag{7}$$

Output is produced with a CES aggregate of regular and non-regular labor:

$$Y_t = px_t \left[\alpha(\chi_R R_t)^\rho + (1-\alpha)(\chi_I I_t)^\rho\right]^{\nu/\rho}. \tag{8}$$

The parameter ρ governs the curvature of the regular/non-regular labor nest, and the elas-

[2]Separately estimating a model-consistent technological curvature jointly with regular-employment adjustment frictions would require a different structural estimation exercise and is beyond the scope of this paper.

ticity of substitution is $\sigma = 1/(1-\rho)$. The parameter ν governs the scale curvature of the labor block in the structural model. Since the structural model abstracts from capital, the auxiliary CES-CD estimate of γ_L is used as an external scale discipline for this labor block; this mapping is a calibration convention. The empirical benchmark imposes $\rho = 0.3100$, which implies $\sigma = 1.4493$. I also consider an alternative complementarity calibration with $\rho = -0.1000$, or $\sigma = 0.9091$. This value is not an alternative estimate; it is an illustrative stress test below the empirical confidence interval.

The effective labor cost of worker type $g \in \{R, I\}$ is

$$C_g = (1 + \tau_g^f) w_g^{gross}, \qquad w_g^{gross} = \frac{w_g^{net}}{1 - \tau_g^w}, \tag{9}$$

where τ_g^f is the employer-side social-insurance rate and τ_g^w is the worker-side contribution rate. In the main benchmark, I set the employer-side rate to 0.1071 for both worker types and the worker-side rate to zero. The zero worker-side rate is a normalization that makes net and gross wages coincide in the benchmark; the counterfactuals are not intended to analyze worker-side tax incidence or labor-supply responses. The policy experiments create relative labor-cost variation only by changing one worker type's employer-side rate.

4.2 Value Functions and Equilibrium

For a given regular employment choice R_t and productivity x_t, the firm chooses non-regular employment from

$$MRP_I(R_t, I_t, x_t) = C_I. \tag{10}$$

Non-regular wages are determined by a spot bargaining rule,

$$w_I^{net} = \eta_I MRP_I + (1 - \eta_I) b_I^{out}. \tag{11}$$

Regular wages use a marginal-jobs-inspired bargaining block with a Stole-Zwiebel-style curvature correction (**?**). In compact form,

$$w_R^{net} = \eta_R \left(\widetilde{MRP}_R + \beta f(\theta) H(\theta) \right) + (1 - \eta_R) b_R^{out}. \tag{12}$$

Here $\widetilde{MRP}_R$ is the curvature-adjusted marginal revenue product of regular labor, $f(\theta)$ is the worker job-finding probability, and $H(\theta)$ is the expected hiring cost. The term $\beta f(\theta)H(\theta)$ captures the hiring-option component that enters the regular-job surplus when a worker's outside option includes the possibility of finding another regular job. This tractable wage block replaces a full two-type Stole-Zwiebel bargaining solution.

The firm's Bellman equation is

$$V(R_{t-1}, x_t) = \max_{R_t \in \mathcal{R}} \Big\{ \Pi(R_{t-1}, R_t, x_t; \theta, b_R, b_I) + \beta E[V(R_t, x_{t+1}) \mid x_t] \Big\}. \tag{13}$$

Given $I_t = I^*(R_t, x_t)$, the flow payoff is

$$\Pi = (1 - \tau_c) \left[Y_t - C_R R_t - C_I I_t \right] - H(\theta) \max\{R_t - R_{t-1}, 0\} - F_R w_R^{gross} \max\{R_{t-1} - R_t, 0\}. \tag{14}$$

The hiring cost is $H(\theta) = \kappa_v w^{ref} / q(\theta)$, where $q(\theta)$ is the vacancy-filling rate and $w^{ref} = 1$ normalizes the reference wage in the vacancy-cost scale. The firing cost is one month of regular gross wages in the benchmark.

The regular labor market is summarized by a matching function,

$$q(\theta) = m\theta^{-a}, \qquad f(\theta) = m\theta^{1-a}. \tag{15}$$

The worker side is kept parsimonious. Following the search-and-matching structure in Elsby and Michaels (2013), the model does not use a family household to choose labor supply, hours, or employment type. The regular labor force is fixed, unemployed regular workers find jobs with probability $f(\theta)$, and the worker-side payoff is summarized by the type-specific outside values b_R^{out} and b_I^{out}. This abstraction keeps the model focused on the policy question: how employer-side labor-cost changes affect firms' dynamic regular-employment decisions and flexible non-regular labor demand. The exercise therefore concerns employment composition and wage responses conditional on labor-force participation, rather than endogenous household labor supply.

Regular labor supply is exogenous. Labor-market tightness θ is not determined by a vacancy free-entry condition. It is selected to satisfy a stationary stock-flow consistency condition for the regular labor market:

$$res(\theta) = (\bar{L}_R - R) - \frac{Sep_R}{f(\theta)}. \tag{16}$$

The first term is the model-implied stock of regular unemployment, where $\bar{L}_R$ is the exogenous regular labor force. The second term is the unemployment stock required to support the stationary regular separation flow Sep_R. Here, Sep_R is the stationary-distribution-weighted sum of $\max\{R_{t-1} - R_t, 0\}$. Aggregate regular hires are defined analogously as the stationary-distribution-weighted sum of $\max\{R_t - R_{t-1}, 0\}$. An equilibrium consists of firm policies, non-regular labor demand, wages, a stationary distribution over (R, x), replacement benefits, and a value of θ. These objects satisfy the firm problem, the non-regular FOC, the wage equations, the stationary distribution, the benefit fixed point, and the stock-flow consistency condition.

4.3 Calibration

Table 3 reports the benchmark calibration. The key empirical input is $\rho = 0.3100$, the COGS+SG&A FOC estimate from Table 1. Conditional on this curvature, the AKP-style level-FE exercise in Table 2 gives the auxiliary production-side estimate $\hat{\gamma}_L = 0.6976$. I use this estimate to set the structural labor-scale parameter to $\nu = 0.6976$. This mapping is a calibration convention for a capital-free structural model, not an identity implied by the auxiliary production function. The production-side exercise profiles the CES weight at $\alpha = 0.7000$. Once the structural model introduces type-specific task efficiency (χ_R, χ_I), however, the empirical exercise should not be interpreted as separately identifying α and χ_R. The calibration therefore sets $\alpha = 0.7500$, close to the empirical production-side profile, and chooses it jointly with $\chi_R = 2.5000$ and $p = 1.3500$. These parameters bring the regular/non-regular wage premium, employment composition, and aggregate scale close to the benchmark targets. For computational tractability, the benchmark monthly discount factor is set to $\beta = 0.99$.[3] Parameters without one-to-one empirical moments are reported as joint target-moment calibration or benchmark normalizations rather than as separately identified estimates.

Parameter	Value	Role	Target/Source	Description
External Calibration and Empirical Inputs				
ρ	0.3100	CES curvature	WPS FOC, COGS+SG&A	external empirical discipline; $\sigma = 1.4493$
ν	0.6976	labor-block scale curvature	AKP-style $\hat{\gamma}_L$	calibration convention; ρ fixed at 0.3100
ρ_x	0.9740	productivity persistence	KoDATA estimate	monthly process
σ_x	0.0786	productivity innovation s.d.	KoDATA estimate	monthly process
β	0.9900	discount factor	benchmark normalization	monthly
τ_c	0.1600	corporate tax	institutional benchmark	profit tax
τ_R^f, τ_I^f	0.1071	employer SI rate	actual policy	equal employer-side rate by type
τ_R^w, τ_I^w	0.0000	assumptions	benchmark normalization	net and gross wages coincide
a	0.6000	matching elasticity	search-block benchmark	$q(\theta) = m\theta^{-a}$
m	0.1290	matching efficiency	search-block benchmark	$f(\theta) = m\theta^{1-a}$
Structural Benchmark Values				
α	0.7500	regular CES weight	joint target-moment calibration	wage premium and employment composition
χ_R	2.5000	regular task efficiency	joint target-moment calibration	$\chi_I = 1.0000$; wage premium and composition
p	1.3500	productivity scale	joint target-moment calibration	aggregate scale
η_R	0.4430	regular bargaining weight	wage-block benchmark	regular wage bargaining
η_I	0.0800	non-regular bargaining weight	wage-block benchmark	non-regular wage bargaining
ϕ_R	0.1600	regular outside-option component	joint wage/employment calibration	$b_R^{out} = b_R + \phi_R$
ϕ_I	0.2500	non-regular outside-option component	joint wage/employment calibration	$b_I^{out} = b_I + \phi_I$
κ_v	0.1327	vacancy cost	regular adjustment benchmark	scaled by $w^{ref}/q(\theta)$
F_R	1.0000	firing cost	regular adjustment benchmark	months of regular gross wage

Notes: SI denotes social insurance. Values are rounded to four decimal places.

Table 3: Structural model calibration.

Unemployment benefits are computed as a fixed point. For each worker type $g \in \{R, I\}$, the cash benefit is

$$b_g = 0.6000\bar{w}_g, \qquad b_g^{out} = b_g + \phi_g. \tag{17}$$

The fixed point is solved with damping and convergence checks on benefits, firm policies, the

[3] The main quantitative conclusions are unchanged under $\beta = (1/1.035)^{1/12} \approx 0.9971$, corresponding to an annual discount rate of 3.5 percent, although the fixed-point algorithm converges substantially more slowly.

stationary distribution, and the stock-flow residual for θ. The numerical details are reported in subsection A.1.

Table 4 reports the benchmark model fit under the empirical value of ρ. The model produces a non-regular employment share of 0.1519 and a regular/non-regular net wage premium of 1.3975, compared with target values of 0.1736 and 1.4286, respectively. These moments matter because the policy experiments operate through relative labor costs and the composition of regular and non-regular employment. The employment-composition targets are the structural calibration targets from the KER benchmark data, not the WPS FOC estimation sample. They therefore differ from the WPS non-regular employment share reported in Table 11.

Benchmark Model Fit			
Moment	Data target	Model	Model – data
Regular employment	6.2244	5.7639	-0.4605
Non-regular employment	1.3078	1.0326	-0.2753
Total employment	7.5322	6.7964	-0.7358
Non-regular employment share	0.1736	0.1519	-0.0217
Regular/non-regular net wage premium	1.4286	1.3975	-0.0311
Regular net wage	–	0.8937	–
Non-regular net wage	–	0.6395	–
Labor-market tightness θ	–	0.9737	–
Output	–	8.1187	–

Notes: Components and aggregates are computed from unrounded model values and may not sum exactly because of rounding. Values are rounded to four decimal places.

Table 4: Benchmark model fit under the empirical ρ.

The main complementarity comparison does not change only ρ. The production-side parameters are recalibrated so that the empirical benchmark is not compared with an implausible wage environment when $\rho = -0.1000$. The recalibrated complementarity case sets $\alpha = 0.8600$, $\chi_R = 3.0000$, and $p = 1.1500$, while keeping the replacement-benefit rule and social-insurance regime fixed. It produces a regular/non-regular net wage premium of 1.4098, close to the target value of 1.4286, total employment of 7.0688 relative to a target of 7.5322, and a non-regular employment share of 0.1999, somewhat above the target value of 0.1736.

I interpret this exercise as a disciplined complementarity stress test rather than as a second empirical calibration. Table 7 reports the corresponding target fit.

4.4 Policy Experiments and Counterfactual Analysis

Stationary equilibria are computed under two employer-side contribution-rate changes. The main experiment raises the non-regular employer-side social-insurance rate by 10 percent, $\tau_I^f \leftarrow 1.10\tau_I^f$. The second lowers the regular employer-side rate by 10 percent, $\tau_R^f \leftarrow 0.90\tau_R^f$. Throughout, a 10 percent change means a proportional change in the existing rate, not a 10 percentage-point change. Thus, the employer-side social-insurance rate of 0.1071 becomes 0.1178 in the non-regular social-insurance experiment. The counterfactuals isolate the employer-cost channel. They do not value insurance benefits received by workers, impose a government budget constraint, or provide a welfare ranking of alternative social-insurance systems. Corporate-tax experiments are omitted from the main quantitative comparison because they do not directly change the relative price of regular and non-regular labor. In the current wage-bargaining block, their effects are small and operate through surplus and wage feedback rather than through the core substitution margin.

Table 5 reports the main policy effects under the empirical benchmark and under the recalibrated complementarity stress test. The stress test is not a one-parameter change in ρ; it also adjusts α, χ_R, and p so that the complementarity case remains comparable in wage-premium and aggregate-scale terms. Parameter-sensitivity cases that vary ρ, α, and χ_R separately are reported in Table 8.

Under the empirical benchmark, increasing the non-regular employer-side contribution rate reduces non-regular employment by 1.8635 percent, total employment by 0.2909 percent, and output by 0.1751 percent. The recalibrated complementarity case gives a smaller non-regular share decline and a slightly smaller output loss: non-regular employment falls by 1.2542 percent, total employment falls by 0.2708 percent, and output falls by 0.1644 percent. The regular/non-regular wage premium falls more in the complementarity stress test,

MAIN POLICY EXPERIMENTS

Case	Policy	ρ	α	χ_R	p	θ	Reg. emp. %	Non-reg. emp. %	Total emp. %	Non-reg. share %	Output %	Reg. wage %	Non-reg. wage %	Wage premium %
Benchmark	Non-regular SI +10%	0.3100	0.7500	2.5000	1.3500	0.9719	-0.0092	-1.8635	-0.2909	-1.5772	-0.1751	-0.1003	0.2375	-0.3370
Benchmark	Regular SI -10%	0.3100	0.7500	2.5000	1.3500	1.0523	0.5138	0.1178	0.4536	-0.3343	0.2681	0.5097	0.0554	0.4541
Full recalibrated	Non-regular SI +10%	-0.1000	0.8600	3.0000	1.1500	0.7555	-0.0250	-1.2542	-0.2708	-0.9861	-0.1644	-0.1557	0.2375	-0.3923
Full recalibrated	Regular SI -10%	-0.1000	0.8600	3.0000	1.1500	0.8269	0.6122	0.3136	0.5525	-0.2376	0.3331	0.4294	0.0412	0.3880

Notes: Entries other than θ and the parameter columns are percent changes from the corresponding baseline. SI denotes social insurance.
Wage premium is the percent change in the regular/non-regular net wage ratio.

Table 5: Main policy effects in the structural model.

reflecting the wage and productivity structure required to keep the $\rho = -0.1000$ economy close to the benchmark calibration targets.

In the regular social-insurance experiment, lowering the regular employer-side rate raises total employment and output in both calibrations. The empirical benchmark gives a 0.4536 percent increase in total employment and a 0.2681 percent increase in output. The recalibrated complementarity case gives somewhat larger gains, 0.5525 percent and 0.3331 percent, respectively, while the decline in the non-regular employment share is smaller. The main complementarity comparison therefore reflects the joint equilibrium effect of the labor-nest curvature, the CES weight, regular task efficiency, and the productivity scale, rather than the substitution elasticity alone. The sensitivity cases in Table 8 show that changing ρ alone would overstate the aggregate role of complementarity relative to the recalibrated stress test.

The final accounting exercise compares the model-implied relative labor-cost change with the relative-cost change implied by the CES employment response. From the CES relative FOC,

$$\Delta \log(\widehat{C}_I/\widehat{C}_R)^{CES} = -\frac{1}{\sigma}\Delta \log(I/R). \tag{18}$$

The model counterpart includes both the endogenous relative wage response and the statutory employer-side social-insurance factor:

$$\Delta \log(C_I/C_R)^{model} = \Delta \log(w_I/w_R) + \Delta \log\left(\frac{1+\tau_I^f}{1+\tau_R^f}\right). \tag{19}$$

The difference between these two objects is reported as a relative-cost transmission residual, not as a separately identified structural friction. A reduced-form elasticity calculation maps relative quantities into a single relative-cost movement. The structural model separates statutory cost shocks, endogenous wage responses, and dynamic regular-employment adjustment.

The residual is nearly zero in the non-regular social-insurance experiment, both under the empirical ρ and under the recalibrated complementarity case. This is an internal consistency

Relative-Cost Transmission Accounting						
ρ case	Policy	Statutory SI %	Model w_I/w_R %	Model C_I/C_R %	CES-implied C_I/C_R %	Residual pp
Empirical $\rho = 0.3100$	Non-regular SI +10%	0.9674	0.3381	1.3088	1.3000	0.0088
Empirical $\rho = 0.3100$	Regular SI -10%	0.9769	-0.4520	0.5204	0.2727	0.2477
Recalibrated $\rho = -0.1000$	Non-regular SI +10%	0.9674	0.3939	1.3651	1.3701	-0.0050
Recalibrated $\rho = -0.1000$	Regular SI -10%	0.9769	-0.3865	0.5866	0.3274	0.2591

Notes: Statutory SI is the change in $(1+\tau_I^f)/(1+\tau_R^f)$. Residual is model C_I/C_R minus CES-implied C_I/C_R, in percentage points. Log changes are converted to exact percentage changes as $100[\exp(\Delta\log(\cdot)) - 1]$.

Table 6: Relative-cost transmission accounting in the structural model.

check: the CES labor nest disciplines the composition response closely once the statutory cost change is included. In contrast, the regular social-insurance cut generates a larger positive residual. This gap is consistent with additional dynamic and equilibrium adjustment in the regular-employment margin, but it is not a separately identified adjustment-cost effect. It may also reflect aggregation, composition changes, nonlinear wage and tightness responses, and numerical approximation. Table 9 reports the associated changes in tightness and regular-worker flows.

5 Conclusion

This paper estimates the substitutability of regular and non-regular workers in South Korea and studies its implications for employer-side labor-cost policies. The benchmark FOC point estimate is $\hat{\rho} = 0.3100$, corresponding to $\hat{\sigma} = 1.4493$. It indicates imperfect substitution, although the estimate is not precise enough to rule out values near the Cobb–Douglas case.

The structural model shows that employer-side contribution-rate changes affect employment composition, wages, labor-market tightness, and aggregate output jointly. A higher non-regular social-insurance rate reduces non-regular employment and lowers total employment and output. A lower regular social-insurance rate raises total employment and output while reducing the non-regular employment share. The recalibrated complementarity exercise shows that the policy effects depend on the wage and productivity structure that accompanies a given value of ρ. Policies aimed at reducing labor-market duality should therefore be evaluated through both the substitution margin and the equilibrium wage and adjustment channels.

AI Disclaimer During the preparation of this work, the author(s) used ChatGPT for Proofreading and computational works. The author(s) reviewed and edited the output as needed and take full responsibility for the content of the published article.

References

An, Zidong, Alvar Kangur, and Chris Papageorgiou, "On the substitution of private and public capital in production," *European Economic Review*, 2019, *118*, 296–311.

_ , _ , and _ , "On the substitution of private and public capital in production," *European Economic Review*, 2019, *118*, 296–311.

Chang, Minsu and Hanbaek Lee, "Bridging Firm-Level and State-Level Input Elasticities: The Fiscal Multiplier of Infrastructure Investment," *Working Paper*, 2023.

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.

Dolado, Juan J., Gergő Motyovszki, and Evi Pappa, "Monetary Policy and Inequality under Labor Market Frictions and Capital-Skill Complementarity," *American Economic Journal: Macroeconomics*, April 2021, *13* (2), 292–332.

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.

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.

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

Koesler, Simon and Michael Schymura, "SUBSTITUTION ELASTICITIES IN A CONSTANT ELASTICITY OF SUBSTITUTION FRAMEWORK – EMPIRICAL ESTIMATES USING NONLINEAR LEAST SQUARES," *Economic Systems Research*, 2015, *27* (1), 101–121.

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.

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

OECD, *OECD Economic Surveys: Korea 2024*, Paris: OECD Publishing, 2024.

Ohanian, Lee E., Musa Orak, and Shihan Shen, "Revisiting capital-skill complementarity, inequality, and labor share," *Review of Economic Dynamics*, 2023, *51*, 479–505.

Statistics Korea, "Supplementary Results of the Economically Active Population Survey by Employment Type in August 2019," Technical Report, Statistics Korea, Daejeon 2019.

Appendices

A Structural Appendix

A.1 Numerical Details

The structural model is solved as a stationary equilibrium. The replacement-benefit fixed point uses damping 0.55, tolerance 2.0×10^{-4}, and at most 12 outer iterations. The numerical benchmark uses an exponential regular-employment grid with $R_{\max} = 160$, 501 state-grid points, 20,000 regular choice-grid points, value-function tolerance 2.5×10^{-5}, stationary-distribution tolerance 1.0×10^{-10}, and a smoothed Young update. The upper bound $R_{\max} = 160$ follows grid checks showing that the previous $R_{\max} = 90$ could be restrictive in the upper tail. The $R_{\max} = 200$ check leaves essentially no mass above 150. For policy experiments, θ is locally refined around the candidate solution until the stock-flow residual in Equation 16 is below the tolerance used for the reported equilibrium.

A.2 Recalibrated Complementarity Fit

Recalibrated Complementarity Target Fit			
Moment	Target	Model	Model – target
Regular employment	6.2244	5.6557	-0.5688
Non-regular employment	1.3078	1.4132	0.1054
Total employment	7.5322	7.0688	-0.4634
Non-regular employment share	0.1736	0.1999	0.0263
Regular/non-regular net wage premium	1.4286	1.4098	-0.0187
Regular replacement rate	0.6000	0.6000	-0.0000
Non-regular replacement rate	0.6000	0.5998	-0.0002

Notes: The table reports the target fit for the recalibrated $\rho = -0.1000$ stress test. Stock-flow residuals are numerical equilibrium diagnostics and are not calibration targets. Values are rounded to four decimal places.

Table 7: Target fit for the recalibrated complementarity case.

A.3 Complementarity Sensitivity

Case	Policy	ρ	α	χ_R	p	θ	Reg. emp. %	Non-reg. emp. %	Total emp. %	Non-reg. share %	Output %	Reg. wage %	Non-reg. wage %	Wage premium %
							Complementarity Parameter Sensitivity							
ρ only	Non-regular SI +10%	-0.1000	0.7500	2.5000	1.3500	0.3450	-0.1142	-1.4370	-0.4979	-0.9438	-0.3422	-0.2583	0.2375	-0.4946
ρ only	Regular SI -10%	-0.1000	0.7500	2.5000	1.3500	0.3950	1.0943	0.6177	0.9561	-0.3351	0.6274	0.1526	0.0412	0.1113
$\rho + \alpha$	Non-regular SI +10%	-0.1000	0.8600	2.5000	1.3500	0.8986	-0.0792	-1.1720	-0.3042	-0.8705	-0.1786	-0.1054	0.1292	-0.2343
$\rho + \alpha$	Regular SI -10%	-0.1000	0.8600	2.5000	1.3500	0.9785	0.4900	0.2727	0.4453	-0.1718	0.2638	0.4760	0.0067	0.4693
$\rho + \chi_R$	Non-regular SI +10%	-0.1000	0.7500	3.0000	1.3500	0.5186	-0.1964	-1.4206	-0.5796	-0.8459	-0.3753	-0.1901	0.1806	-0.3700
$\rho + \chi_R$	Regular SI -10%	-0.1000	0.7500	3.0000	1.3500	0.5936	0.8642	0.4439	0.7326	-0.2866	0.4717	0.2733	0.0551	0.2181

Notes: Entries other than θ and the parameter columns are percent changes from the corresponding baseline. SI denotes social insurance.
Rows are computed around different baseline steady states and are not additive components of a formal channel analysis.
Wage premium is the percent change in the regular/non-regular net wage ratio. Values are rounded to four decimal places.

Table 8: Sensitivity of policy effects around the complementarity stress test.

A.4 Mechanism Accounting Details

Table 9 reports the changes in labor-market tightness and regular-worker flows that accompany the relative-cost accounting in Table 6. The table is an accounting summary around the reported policy equilibria. It is not a closed-form channel attribution, because the entries are equilibrium objects and move jointly.

Mechanism Accounting for Policy Transmission							
ρ case	Policy	Statutory SI %	w_I/w_R %	θ %	Hires %	Separations %	Residual pp
Empirical $\rho = 0.3100$	Non-regular SI +10%	0.9674	0.3381	-0.1883	-0.0278	-0.0260	0.0088
Empirical $\rho = 0.3100$	Regular SI -10%	0.9769	-0.4520	8.0720	-0.8049	-0.7807	0.2477
Recalibrated $\rho = -0.1000$	Non-regular SI +10%	0.9674	0.3939	-0.4830	0.0223	0.0236	-0.0050
Recalibrated $\rho = -0.1000$	Regular SI -10%	0.9769	-0.3865	8.9221	-0.8332	-0.8342	0.2591

Notes: Hires and separations refer to regular-worker flows. Residual is model C_I/C_R minus CES-implied C_I/C_R, in percentage points. Rows are accounting summaries and are not additive components of a formal channel attribution. Values are rounded to four decimal places.

Table 9: Policy transmission through relative costs, tightness, and regular-worker flows.

B Empirical Appendix

Sample Construction for the FOC Estimation		
Sample step	Observations	Establishments
Full WPS panel	18,016	4,985
Valid employment accounting	13,907	4,503
Positive sales and non-missing output	10,034	3,717
2015–2019 waves	6,501	2,936
Positive regular and non-regular employment	3,054	1,747
Non-missing relative wage proxy	2,617	1,518
Non-missing core controls	2,613	1,517
Non-missing COGS+SG&A controls	2,527	1,489

Notes: The final row corresponds to the benchmark COGS+SG&A FOC specification.
The relative wage proxy is available only in the 2015, 2017, and 2019 WPS waves.

Table 10: Sample construction for the relative input-demand estimation.

Summary Statistics: Benchmark FOC Sample						
Variable	Mean	Std. dev.	25th pct.	Median	75th pct.	Obs.
Regular employment	324.5667	711.9033	50.0000	131.0000	352.5000	2,527
Non-regular employment	165.6945	589.4987	11.0000	37.0000	136.0000	2,527
Non-regular employment share	0.3009	0.2929	0.0680	0.1923	0.4383	2,527
Relative wage/labor cost	0.8868	0.1247	0.8000	0.9000	1.0000	2,527
Sales, real	250,120.1562	1,234,016.0000	12,218.2500	35,666.4727	123,144.3711	2,527
Capital, real	119,619.4688	628,248.1875	1,590.7003	10,519.7988	47,100.9043	2,527
COGS, real	188,417.1094	999,351.6875	5,659.0366	22,561.0000	85,905.5469	2,527
SG&A, real	33,173.6094	275,746.7500	1,992.6163	5,521.2207	18,807.3350	2,527
Establishment age	28.0447	16.0413	16.0000	25.0000	38.0000	2,527

Notes: Statistics are unweighted and computed for the benchmark FOC sample.
Real financial variables are CPI-adjusted with 2015 as the base year.

Table 11: Summary statistics for the benchmark empirical sample.

Relative Wage Proxy Diagnostics							
Proxy	Mean	Std. dev.	25th pct.	Median	75th pct.	Obs.	Establishments
Direct non-regular types only	0.8961	0.1220	0.8000	0.9000	1.0000	2,275	1,323
Direct plus subcontract/service category	0.8872	0.1244	0.8000	0.9000	1.0000	2,617	1,518
Baseline: direct plus all indirect workers	0.8865	0.1246	0.8000	0.9000	1.0000	2,617	1,518

Notes: Statistics are computed for observations satisfying the FOC sample restrictions before control-specific exclusions.
The baseline assigns the subcontract/service relative wage to the full indirect-employment category.

Table 12: Alternative constructions of the non-regular relative wage proxy.

FOC Robustness to Alternative Relative Wage Proxies							
Proxy	$\hat{\sigma}$	s.e.	$\hat{\rho}$	s.e.	95% CI for ρ	Obs.	Establishments
Direct non-regular types only	0.8847	0.3820	-0.1303	0.4881	[-1.0869, 0.8263]	2,186	1,294
Direct plus subcontract/service category	1.4445	0.3516	0.3077	0.1685	[-0.0226, 0.6380]	2,527	1,489
Baseline: direct plus all indirect workers	1.4493	0.3515	0.3100	0.1674	[-0.0181, 0.6380]	2,527	1,489
Winsorized baseline proxy	1.5125	0.3588	0.3388	0.1569	[0.0314, 0.6463]	2,527	1,489

Notes: The dependent variable is $\log(R_{it}/I_{it})$. All specifications include establishment fixed effects, year fixed effects, capital, COGS, SG&A, establishment age, and establishment age squared.
The direct-only proxy is based on a narrower worker set and is not coverage-equivalent to the baseline non-regular employment measure.
Standard errors are clustered at the establishment level. Values are rounded to four decimal places.

Table 13: Robustness of the FOC estimates to alternative relative wage proxy construction.

Leave-One-Out Relative Labor-Cost Robustness						
Specification	$\hat{\sigma}$	s.e.	$\hat{\rho}$	s.e.	Obs.	Establishments
Core	1.7262	1.5729	0.4207	0.5279	2,019	1,213
COGS only	1.8794	1.5871	0.4679	0.4493	1,972	1,200
SG&A only	1.7675	1.5748	0.4342	0.5041	2,009	1,208
COGS+SG&A	1.8815	1.5887	0.4685	0.4488	1,970	1,199

Notes: The regressor is the industry-region-year leave-one-out relative labor-cost proxy.
All specifications include establishment fixed effects and industry-year fixed effects.
Standard errors are clustered at the establishment level. Values are rounded to four decimal places.

Table 14: FOC estimates using leave-one-out relative labor-cost measures.

Profile Diagnostics for the CES Production Exercise						
Scenario	ρ	σ	α	γ_L	RSS loss (%)	Within R^2
Profile minimum	0.9900	100.0000	0.7000	0.7146	0.0000	0.6687
Best admissible interior	0.9000	10.0000	0.7000	0.7145	0.0463	0.6685
FOC ρ imposed	0.3100	1.4493	0.7000	0.6976	4.9707	0.6522

Notes: The table reports the COGS+SG&A level-FE profile.
Values are rounded to four decimal places.

Table 15: Production-side profile diagnostics.

Industry Heterogeneity in FOC Estimates					
Group	$\hat{\sigma}$	s.e.	$\hat{\rho}$	95% CI for ρ	Obs.
Manufacturing	2.7269	0.6675	0.6333	[0.4574, 0.8092]	1,009
Services	0.8089	0.3569	-0.2363	[-1.3054, 0.8328]	1,223
Other industries	0.6923	1.5825	-0.4444	[-6.9154, 6.0266]	295

Notes: Each row reports a separate establishment fixed-effects regression.
Standard errors are clustered at the establishment level.

Table 16: Heterogeneity in the regular/non-regular substitution elasticity.