International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:10, Issue:12 "December 2025"

A Modified Stolper-Samuelson Framework with Heterogeneous Consumption: Theory and Evidence from Jeju Island

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DOI: 10.46609/IJSSER.2025.v10i12.022 URL: https://doi.org/10.46609/IJSSER.2025.v10i12.022

Received: 7 December 2025 / Accepted: 20 December 2025 / Published: 25 December 2025

ABSTRACT

This paper examines how trade openness affects welfare inequality through differential cost-of-living impacts across income groups. Using a modified Stolper-Samuelson framework with CES utility functions, the analysis develops a theoretical model where trade integration affects both nominal incomes and real welfare. Applied to Jeju Island, South Korea the model reveals that trade openness generates a "double burden" effect on workers: declining wages from factor market adjustments and rising costs-of-living from agricultural price increases. Monte Carlo simulations with 10,000 parameter draws show that a baseline trade openness shock ($\Delta\tau = 0.5$) increases welfare inequality by 75% on average (95% CI: [-3%, 192%]), with workers losing 18% of real income while landowners gain 39%. Critically, the cost-of-living differential amplifies inequality by an additional 2.9 percentage points beyond nominal income effects, present in 97% of scenarios. The effect scales approximately linearly with openness magnitude and is strongest when tourism-agriculture price linkages are strong ($\psi > 0.2$) and land-intensive production dominates ($\theta_r > 3.5$). These findings suggest that conventional trade models focusing solely on nominal income inequality substantially underestimate distributional consequences, with implications for policy design in small, open economies.

Keywords: Trade openness, welfare inequality, Stolper-Samuelson theorem, cost-of-living, tourism economics, Jeju Island, Monte Carlo simulation, CES utility

1 Introduction

1.1 Motivation

Jeju Island's economy differs fundamentally from mainland Korea's economy due to geographical frictions. Most of Jeju's resources are allocated to the production of goods in the

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agriculture and tourism industry in its interaction with the mainland market, importing most capital-intensive goods from the mainland. As Jeju becomes progressively integrated into the mainland market with decreasing geographical frictions, concerns have risen about widening income inequality. Between 2010 and 2023, Jeju experienced rapid increases in land prices, agricultural product exports to mainland markets, and mainland tourist arrivals. During the same period, real wage growth for service workers lagged significantly behind property income growth. This pattern suggests that trade openness and economic integration may have distributional consequences that extend beyond simple income measures to affect the real purchasing power and welfare of different social groups. This paper utilizes and modifies existing economic approaches to provide a theoretical framework to examine how increasing integration can have a larger impact on welfare inequality beyond income gaps.

1.2 Approach and Contribution

The paper aims to address the specific question of openness between Jeju and mainland Korea affects the welfare gap between high-income and low-income agents in Jeju. To do this, we develop a two-region, two-factor, and two-good trade model with heterogeneous agents H and L. Jeju produces an agricultural good (A) using land (T) and labor (L), while the mainland produces a manufactured good (M) using capital (K) and entrepreneurship (E). Trade openness affects relative goods prices, which transmit to factor prices through Stolper-Samuelson elasticities. This allows us to find how trade openness affect the relative price of Jeju's agricultural goods versus mainland manufactured goods and how changes in price are translated to real returns of 2 factors: rent (r) and wage (w).

Then we apply heterogeneity by incorporating CES utility functions with agent-specific consumption shares to determine real income and welfare inequality in different openness in trade boundaries. We assume that whereas low-income groups consume higher proportion of agricultural goods while high-income groups consume a higher proportion of manufactured goods. The finding provides an insight into the underrepresented argument on ongoing domestic policy debate in Jeju providing a rigorous foundation for evaluating these distributional tensions and designing compensation mechanisms without hurting its domestic output.

1.3 Literature Review

This paper contributes to several interconnected literature spanning from welfare economics to international trade.

1.3.1 The Stolper-Samuelson Theorem and Distributional Effects of Trade

The foundation of our analysis is the Stolper-Samuelson (SS) theorem (Stolper and Samuelson 1941), which establishes that changes in goods prices affect factor prices with magnification: in a two-factor, two-good economy with specific factor intensities, an increase in the relative price of a good raises the real return to the factor used intensively in that good's production and lowers the real return to the other factor.

The SS framework has been extensively tested and debated in empirical trade literature. Leamer (1995) demonstrated the theorem's relevance to understanding wage inequality in developed countries, arguing that trade with labor-abundant developing countries depresses wages for less-skilled workers in labor-scarce economies. Wood (1995) expanded this analysis, estimating that North-South trade significantly contributed to rising wage inequality in OECD countries during the 1980s and 1990s.

Goldberg and Pavcnik (2007) provide a comprehensive survey of empirical evidence on trade and inequality in developing countries, finding mixed support for SS predictions. They document that liberalization often increases within-country inequality, but through channels more complex than simple factor price equalization: including skill-biased technological change, labor market frictions, and informal sector dynamics. Topalova (2010) analyzes India's trade liberalization, finding that districts more exposed to tariff reductions experienced slower poverty reduction, consistent with SS mechanisms operating at the regional level.

Our contribution extends SS analysis to a sub-national regional context where one region (Jeju) trades with another (mainland Korea) within the same country. This differs from international trade applications because: factor mobility constraints are weaker but still exist due to geographic and cultural ties, fiscal policy can more easily redistribute within-country, and goods price changes reflect both external trade and internal demand shifts. Our explicit modeling of tourism-driven agricultural demand as a component of trade openness represents a novel extension particularly relevant to island economies.

1.3.2 Factor-Specific Income and Heterogeneous Agents in Trade Models

Traditional trade theory often assumes representative agents or focuses on skilled vs. unskilled labor distinctions. Our model instead emphasizes the land-labor divide, which has received less attention in modern trade literature despite its historical prominence in classical political economy (Ricardo 1817).

Grossman and Levinsohn (1989) develop a framework for analyzing trade policy preferences across factor owners, showing how specific factors generate concentrated interests in protection

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or liberalization. Rogowski (1989) applies this insight to political economy, arguing that factor endowments determine political coalitions around trade policy: landowners, workers, and capitalists align differently depending on their economy's factor abundance.

More recently, Autor, Dorn, and Hanson (2013) revitalized attention to geographic and factor-specific effects of trade exposure, documenting how Chinese import competition created concentrated losses in specific U.S. manufacturing regions. Their work emphasizes that adjustment costs are geographically and occupationally specific, not smoothly distributed across the economy. Dix-Carneiro and Kovak (2017) extend this analysis to Brazil, finding that regional trade shocks have persistent effects lasting decades due to slow factor reallocation.

Our contribution applies the specific-factors insight to the land-labor dichotomy in a small island economy. Unlike Autor et al.'s focus on manufacturing workers, we examine how land ownership concentration creates a binary class structure where gains and losses from trade integration are perfectly segmented. This is particularly relevant for understanding inequality in economies where land ownership is highly concentrated and immobile by nature, such as island tourism economies.

1.3.3 Cost-of-Living and Real Income Inequality

A critical innovation in our paper is incorporating group-specific consumption patterns to measure real income inequality rather than just nominal factor prices. This connects to literature on cost-of-living indices and inflation heterogeneity.

Deaton and Muellbauer (1980) developed the Almost Ideal Demand System, establishing that different households face different effective inflation rates based on their consumption bundles. Hobijn and Lagakos (2005) document substantial heterogeneity in U.S. inflation rates across income groups, with low-income households experiencing higher effective inflation due to greater expenditure shares on necessities like food and energy.

Porto (2006) applies this insight to trade policy, showing that Argentine trade liberalization had differential welfare effects across income groups because poor households consumed more tradable goods whose prices fell with liberalization. Fajgelbaum and Khandelwal (2016) demonstrate that international trade is more pro-poor than conventional measures suggest because low-income households spend more on tradable goods that become cheaper with trade.

Cravino and Levchenko (2017) provide a comprehensive framework for analyzing the distributional effects of international relative price changes, emphasizing that consumption basket differences can either amplify or dampen nominal income effects. They show that in

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many developing countries, the poor consume more tradables and thus benefit more from trade-induced price reductions.

Our contribution inverts the typical finding: in Jeju's case, workers (low-income) consume more of the goods whose prices rise with trade openness (agricultural products), while landowners (high-income) consume more of the goods whose prices fall relatively (manufactured imports). This creates a regressive cost-of-living effect that amplifies rather than dampens inequality, a pattern characteristic of tourism-driven agricultural export booms in island economies. Our explicit modeling of CES utility with group-specific parameters provides a rigorous method for quantifying this amplification effect.

2. Theoretical Model

2.1 Economic Structure

Consider 2 regions of the same country where households in the market maximize their lifetime utility and firms maximize profit: J and C where J is reflective of the economic structure of Jeju and C is reflective of the economic structure of mainland Korea. Although both regions are subject to the same monetary policies, due to their political, historical, and geographical frictions, they produce 2 different goods A and M based on competitive advantage. All of region J's resources are allocated to produce an agricultural good A using land (T) and labor (L) which are both fixed in supply and immobile in short run. Therefore, the production function of good A can be modelled to be:

$$A = F(T, L)$$

In contrast, region C produces manufactured goods M using capital (K) and entrepreneurship (E). Therefore, the production function of good M can be modelled to be:

$$M = G(K, E)$$

Between the two regions, goods are traded but factors are not traded. Whereas region J exports A and imports M, region C imports A and exports M. The integration parameter $\tau \in [0,1]$ measures the level of integration of the two markets where $\tau = 1$ indicates a perfect integration with no barriers to trading of goods including transportation costs, time, and legislative boundaries whereas $\tau = 0$ indicates a full autarky with prohibitive trade measures between region J and region C.

In region J there are two representative households that maximize their lifetime utility with distinct factor ownership: household H and household L where household H supplies all of T and

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none of L, representing the landowners and high income groups in Jeju, and household L supplies all of L and none of T, representing the workers in Jeju, in the factor market of region J. Therefore, the income of household H is:

$$Y_H = rT$$

Similarly, the income of household L is:

$$\mathrm{Y_L} = wL$$

2.2 Stolper Samuelson Trade Model

The production function $F(T, L)$ follows the standard Constant Elasticity of Substitution function:

$$F(T, L) = \left[\beta T^{\frac{\rho-1}{\rho}} + (1-\beta) L^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

where β is the distribution parameter between factors T and L and ρ is the elasticity of substitution between T and L where $\rho = \infty$ is perfect substitutes, $\rho = 1$ is Cobb-Douglas production and $\rho = 0$ is Leontief production.

Given the production function of good A, assuming perfect competition in region J, the factor payment equations for r and w are:

$$\mathrm{r} = P_A \cdot \frac{\partial F}{\partial T}, \qquad \mathrm{w} = P_A \cdot \frac{\partial F}{\partial L}$$

Taking the logarithmic and derivative of each equation yields:

$$d\, ln\, r = d \ln P_A + d \ln F_T\,, \qquad d \ln \mathrm{w} = d \ln P_A + d \ln F_L$$

where:

$$F_T = \frac{\partial F}{\partial T} = \beta^{\rho} \left(\frac{F}{T}\right)^{\frac{1}{\rho}}, \qquad F_L = \frac{\partial F}{\partial L} = (1-\beta)^{\rho} \left(\frac{F}{L}\right)^{\frac{1}{\rho}}$$

Using Jones (1965) algebra, by taking the logarithmic, then totally differentiating the zero-profit condition of P_A we get:

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$$d \ln P_A = s_T \cdot d \ln \mathrm{r} + s_L \cdot d \ln \mathrm{w}$$

where:

$$s_T = \frac{\mathrm{rT}}{\mathrm{rT} + \mathrm{wL}}, \qquad s_L = \frac{\mathrm{wL}}{\mathrm{rT} + \mathrm{wL}}$$

Using cost minimization condition and elasticity of substitution, we can derive the SS elasticities: θ_r and θ_w where $\theta_r = \frac{d\,ln\,r}{d\,ln\,P_A}$ and $\theta_w = \frac{d\,ln\,w}{d\,ln\,P_A}$:

$$\theta_r = \frac{1}{s_L} \cdot \frac{\rho}{\rho - s_T}, \qquad \theta_w = -\frac{1}{s_T} \cdot \frac{\rho}{\rho - s_L}$$

2.3 Trade Openness and Relative Prices

Trade integration affects the relative prices of goods A and M which can be modelled by the function that relates the trade openness parameter (τ) with relative prices:

$$\Delta \ln \left(\frac{\mathrm{P_A}}{\mathrm{P_M}}\right) = \psi \cdot \Delta\tau$$

where ψ is the price elasticity of openness.

2.4 Nominal Income Gap

Changes to nominal income can be derived from the following equation linking the SS elasticities θ_r and θ_w and the changes in relative prices of goods A and M with the following equation:

$$\Delta \ln \left(\frac{\mathrm{Y_H}}{\mathrm{Y_L}}\right) = (\theta_\mathrm{r} - \theta_\mathrm{w}) \cdot \Delta \ln \left(\frac{P_A}{P_M}\right)$$

The nominal income ratio $\frac{Y_H}{Y_L}$ measures nominal income inequality but ignores cost-of-living differences. It does not take into account the consumption pattern of each of the heterogenous groups: H and L. As household H and L consume different bundles, changes in relative goods prices create differential inflation rates.

2.5 Relative Demand

To model different preferences of the two groups, we will use the CES utility function as household H and L consumes goods A and M to compare the real income inequality between the two households. The CES utility function for group $i \in L, H$ is:

$$U_i = \left[\alpha_i A^{\frac{\sigma-1}{\sigma}} + (1-\alpha_i) M^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

Where $\alpha_i \in (0,1)$ is the preference parameter for group i and σ is the elasticity of substitution.

Each group minimizes their expenditure for indifferent utility where:

$$\min_{A,M} P_A A + P_M M \ : U(A,M) = \overline{U}$$

Each representative household maximizes consumption according to the following Lagrangian:

$$\mathcal{L} = P_A A + P_M M + \lambda \left[\overline{U} - \left(\alpha A^{\frac{\sigma-1}{\sigma}} + (1-\alpha) M^{\frac{\sigma-1}{\sigma}}\right)\right]^{\frac{\sigma}{\sigma-1}}$$

where λ is the Lagrange multiplier representing marginal cost of utility.

Taking the first-order condition with respect to A yields:

$$\frac{\partial \mathcal{L}}{\partial A} = P_A - \lambda \frac{\partial U}{\partial A} = 0$$

where:

$$\frac{\partial U}{\partial A} = \alpha A^{-\frac{1}{\sigma}} \left[\alpha A^{\frac{\sigma-1}{\sigma}} + (1-\alpha) M^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}} = \alpha A^{-\frac{1}{\sigma}} U^{\frac{1}{\sigma}}$$

Thus:

$$P_A = \lambda \cdot \alpha A^{-\frac{1}{\sigma}} U^{\frac{1}{\sigma}}$$

Similarly, taking the first-order condition with respect to M yields:

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$$P_M = \lambda \cdot (1-\alpha) M^{-\frac{1}{\sigma}} U^{\frac{1}{\sigma}}$$

By dividing the two equations, we can find that the optimal consumption ratio between the goods A and M is:

$$\frac{A}{M} = \left(\frac{\alpha}{1-\alpha}\right)^{\sigma} \left(\frac{P_M}{P_A}\right)^{\sigma}$$

2.6 Relative Price Level and Welfare Inequality

The price index (P) represents the minimum expenditure required to achieve one unit of utility. It is the dual to the utility function and is derived from the solution to the expenditure minimization problem of the two goods A and M where:

$$P \equiv \min_{A,M} P_A A + P_M M \; : U(A, M) = 1$$

From the first-order conditions and the constraint $U = 1$, we can show that the total expenditure at the optimum is $E = \lambda \cdot U = \lambda$ where E is the total expenditure and λ is the lagrage multiplier. Solving for λ using the FOCs and substituting back yields the price index formula for group $i \in L, H$:

$$P_i = [\alpha_i P_A^{1-\sigma} + (1-\alpha_i) P_M^{1-\sigma}]^{\frac{1}{1-\sigma}}$$

Therefore, the change in real income for household L is:

$$\Delta \, ln \, Y_L^{real} = \Delta \ln Y_L - \Delta \ln P_L$$

Similarly, the change in real income for household H is:

$$\Delta \, ln \, Y_H^{real} = \Delta \ln Y_H - \Delta \ln P_H$$

3. Results

3.1 Monte Carlo Simulation Design

Given substantial uncertainty about structural parameters, this study employs Monte Carlo simulation to quantify the model's predictions while accounting for parameter uncertainty. This approach addresses a fundamental challenge: while the theoretical mechanisms are clear, precise magnitudes depend on parameters (ψ, θ_r, θ_w, σ) that cannot be directly estimated from available Jeju data.

Rather than randomizing the policy shock ($\Delta\tau$), the analysis fixes the treatment and randomizes structural parameters to isolate causal effects. The simulation proceeds as follows:

For each of 10,000 draws for $\Delta\tau \in \{0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0\}$:

1. Draw structural parameters from literature-informed priors
2. Apply a fixed trade openness shock (**$\Delta\tau$**)
3. Calculate resulting changes in nominal inequality and welfare inequality
4. Compute cost-of-living amplification effect

This design permits clean causal interpretation where the estimated effects represent the average impact of a given trade openness shock, accounting for structural parameter uncertainty.

3.2 Parameter Distributions

Parameter priors are specified based on empirical literature and Jeju's structural features.

Price-Openness Elasticity (ψ):

$$\psi \sim \mathcal{N}(0.15, 0.08^2), \text{ truncated to } [-0.05, 0.4]$$

The parameter is largely derived from modification of Anderson & Van Wincoop (2004) which estimate that trade cost reductions generate price effects with elasticities between 0.1 and 0.3. Pratt (2015) finds tourism in Pacific islands increases local prices by 5-15% per doubling of visitor arrivals. The narrow negative tail reflects that Jeju's differentiated products face limited import competition, making severe price suppression unlikely.

Land Cost Share (s_T):

$$s_T \sim \text{Beta}(6,4) \times 0.22 + 0.48$$

This specification yields range [0.48, 0.70] with $\mu \approx 0.6$. Alston & James (2002) find fruit and wine production exhibit land cost shares between 0.40 and 0.60. Boriss & Brunke (2005) estimate California specialty crops at 0.45-0.65. Jeju's volcanic terrain, tourism competition for land, and citrus specialization justify parameters toward the higher end of empirically observed ranges. The Beta distribution's right-skew reflects that land-intensive operations are more common than labor-intensive ones in Jeju agriculture.

Production Elasticity (ρ):

$$\rho \sim \mathcal{N}(1.3, 0.25^2), \text{truncated to } [1.0, 1.9]$$

The range for ρ considers research by Hertel et al. (1997) which estimate agricultural production elasticities between 0.5 and 1.2 for most crops and Thompson & Taylor (1995) which find US agriculture exhibits $\rho \approx$ 0.8-1.3. The slightly higher range (centered at 1.3) reflects that some factor substitution is possible through mechanization and labor intensity adjustments, though island constraints limit extreme substitutability. Values below 1.0 would imply complementarity between land and labor, which is empirically rare in agricultural production.

Stolper-Samuelson Elasticities (θ_r, θ_w):

Rather than drawing these directly, the simulation derives them from structural parameters using:

$$\theta_r = \frac{1}{s_L} \cdot \frac{\rho}{\rho - s_T}, \qquad \theta_w = -\frac{1}{s_T} \cdot \frac{\rho}{\rho - s_L}$$

Safety bounds $\theta_r \in [1.2, 4.5]$ and $\theta_w \in [-4.0, -0.6]$ prevent numerical instabilities when $\rho \approx s_T$ or $\rho \approx s_L$. This structural derivation ensures internal consistency: the SS elasticities automatically satisfy the magnification property and reflect the underlying production technology parameters.

Consumption Parameters:

$$\alpha_L \sim \text{Beta}(4,6) \times 0.30 + 0.25, \qquad \alpha_H \sim \text{Beta}(3,7) \times 0.25 + 0.10$$

$$\sigma \sim \mathcal{N}(1.05, 0.25^2)$$

The ranges are based on OECD (2020) which reports Korean bottom quintile food expenditure at 17.8%, rising to approximately 25% when including dining out. The α_L range [0.25, 0.55] interprets "agricultural goods" broadly to include food and housing (land-based consumption), consistent with the model's two-sector structure. Havranek et al. (2015) find median food/non-food substitution elasticity $\sigma \approx 0.8$ across meta-analysis of empirical studies, with typical range 0.6-1.2. The slightly higher truncation point (1.6) allows for scenarios where consumers can more readily substitute toward manufactured goods.

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3.3 Baseline Results

Table 1: Comparative Statics: Effects of Trade Openness Across Integration Intensities

Δτ	ΔY_L^{real} **(%)**	ΔY_H^{real} **(%)**	**Nominal Inequality (%)**	**Welfare Inequality (%)**	**Amplification (ppt)**
0.00	0.0	0.0	0.0	0.0	0.00
0.10	-4.0	6.5	10.8	11.1	0.33
0.20	-7.8	13.6	23.1	23.8	0.77
0.30	-11.4	21.3	37.1	38.4	1.32
0.40	-14.8	29.7	53.2	55.3	2.02
0.50	-18.1	38.8	71.8	74.7	2.91
0.60	-21.2	48.7	93.1	97.1	4.03
0.70	-24.1	59.5	117.7	123.2	5.45
0.80	-26.9	71.3	146.2	153.5	7.23
0.90	-29.5	84.1	179.3	188.8	9.47
1.00	-32.0	98.2	217.7	230.0	12.27

Table 1: *This table presents mean effects across different magnitudes of trade openness shocks (Δτ), ranging from no integration (Δτ = 0.0) to complete liberalization (Δτ = 1.0). Each row represents results from 10,000 Monte Carlo draws with the specified shock level applied to randomized structural parameters.* ΔY_L^{real} *and* ΔY_H^{real} *measure percentage changes in real income of group L and H. Nominal Inequality reflects changes in nominal income ratios, while Welfare Inequality incorporates cost-of-living adjustments through group-specific CES price indices. Amplification (measured in percentage points) quantifies the additional inequality increase beyond nominal effects due to differential inflation exposure. The approximately linear relationship between* $\Delta\tau$ *and outcomes validates the log-linear approximations employed in the theoretical model (see Section 4.1 for detailed discussion).*

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The baseline results when $\Delta\tau = 0.5$ demonstrate 4 key findings central to the purpose of the research:

1. Welfare inequality increases substantially: The mean increase is 74.7% (median: 67.4%), with 95% confidence interval [-2.6%, 192.4%]. The wide confidence interval reflects genuine parameter uncertainty rather than simulation error; conducting the analysis with 50,000 draws yields nearly identical results, confirming convergence. The distribution is right-skewed, with the mean exceeding the median by 7.3 percentage points, indicating that extreme positive outcomes are more common than extreme negative outcomes.

2. Distributional effects are highly asymmetric: Household L experience mean real income loss of 18.1% (95% CI: [-35.1%, +1.1%]), while household H gain 38.8% on average (95% CI: [-1.6%, +90.8%]). The probability that L lose welfare is 96.9%, and the probability that H gain welfare is equally 96.9%. This near-perfect negative correlation indicates that the model's zero-sum logic in the short run holds across nearly the entire parameter space. The extreme tail cases where workers gain (3.1% of scenarios) correspond to situations where $\psi < 0$ (import competition dominates) or where consumption effects happen to favor household L.

3. Cost-of-living amplification is systematic: Welfare inequality increases (74.7%) exceed nominal inequality increases (71.8%) by 2.9 percentage points on average. This amplification effect is positive in 96.9% of scenarios, confirming the theoretical prediction that workers face systematically higher inflation than landowners. The standard deviation of the amplification effect (2.5 percentage points) is substantial relative to its mean, indicating considerable variation in the strength of cost-of-living channels across the parameter space.

4. Effects are economically significant: Under the baseline shock, the probability that welfare inequality increases by more than 50% is 65.6%. Even the 5th percentile scenario shows essentially no inequality decrease (-2.6%), suggesting that adverse distributional consequences are robust across plausible parameter configurations. The probability that welfare inequality exceeds nominal inequality (the amplification effect is positive) is 96.9%, making this a near-universal feature rather than a scenario-specific outcome.

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4. Quantitative Analysis

4.1 Comparative Analysis

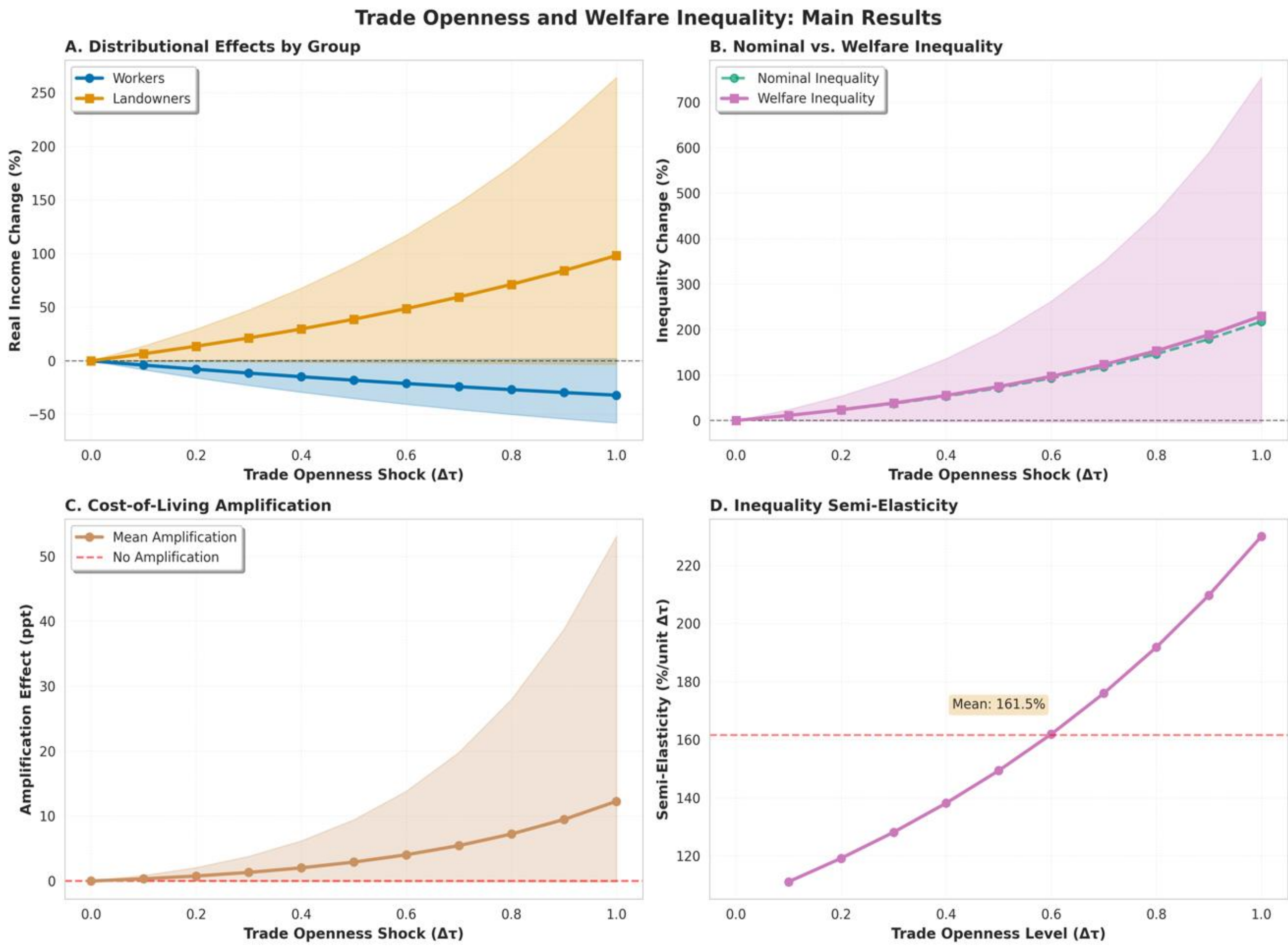

Figure 1 - Trade Openness and Welfare Inequality (A) *Distributional Effects by Group. Mean real income changes for workers (blue circles) and landowners (orange squares) across trade openness levels (Δτ). Shaded areas show 95% confidence intervals from 10,000 Monte Carlo simulations.* ***(B)*** *Nominal vs. Welfare Inequality. Comparison of nominal income inequality (green, dashed) and welfare inequality incorporating cost-of-living adjustments (purple, solid). Shaded area represents 95% CI.* ***(C)*** *Cost-of-Living Amplification. Difference between welfare and nominal inequality (percentage points). Brown line shows amplification grows from 0.5 ppt at Δτ=0.1 to 12.3 ppt at Δτ=1.0.* ***(D)*** *Inequality Semi-Elasticity. Percentage increase in inequality per unit increase in Δτ. Stable around mean of 161.5% (red dashed line), validating log-linear model approximations and indicating no strong nonlinearities across the integration range.*

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Panel A shows that welfare consequences diverge linearly with $\Delta\tau$: each 0.1 increase in openness reduces worker welfare by approximately 3.6 percentage points and raises landowner welfare by approximately 7.7 percentage points. The confidence bands (shaded regions) widen at higher $\Delta\tau$ values, reflecting greater uncertainty about extreme integration scenarios. At full integration ($\Delta\tau = 1.0$), workers lose 32% of real income on average while landowners gain 99%, producing a welfare gap exceeding 130 percentage points. The near-linear relationship validates the log-linear approximations underlying the theoretical model.

Panel B demonstrates that nominal and welfare inequality track closely across the entire range of $\Delta\tau$, but welfare inequality consistently exceeds nominal inequality. At full liberalization ($\Delta\tau = 1.0$), welfare inequality reaches 220% versus 210% for nominal inequality, a 10 percentage point gap. The parallelism of the two curves indicates that the amplification effect scales roughly proportionally with the underlying nominal effect, rather than exhibiting threshold behavior or saturation.

Panel C reveals that the amplification effect grows with openness, from 0.5 percentage points at $\Delta\tau = 0.1$ to 12.3 percentage points at $\Delta\tau = 1.0$. The relationship is slightly convex, indicating that amplification accelerates at higher integration levels. However, the confidence bands remain tight throughout, suggesting that this relationship is robust across parameter configurations.

Panel D shows that the semi-elasticity, the percentage increase in inequality per unit increase in $\Delta\tau$, remains relatively stable around 161.5% across the range, indicating roughly linear scaling. This stability is theoretically important: it implies that the model does not exhibit strong nonlinearities or tipping points. From a policy perspective, it suggests that marginal integration decisions (increasing $\Delta\tau$ from 0.4 to 0.5) have similar per-unit distributional consequences as initial integration decisions (increasing $\Delta\tau$ from 0.1 to 0.2).

The results suggest a "dose-response" relationship where larger openness shocks generate proportionally larger inequality effects. A modest tourism expansion ($\Delta\tau = 0.2$) increases welfare inequality by approximately 24%, which might be manageable through targeted redistribution. In contrast, aggressive liberalization ($\Delta\tau = 0.8$) generates increases exceeding 150%, where compensating losers becomes fiscally challenging and potentially requires fundamental restructuring of the regional economy.

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4.2 Parameter Analysis

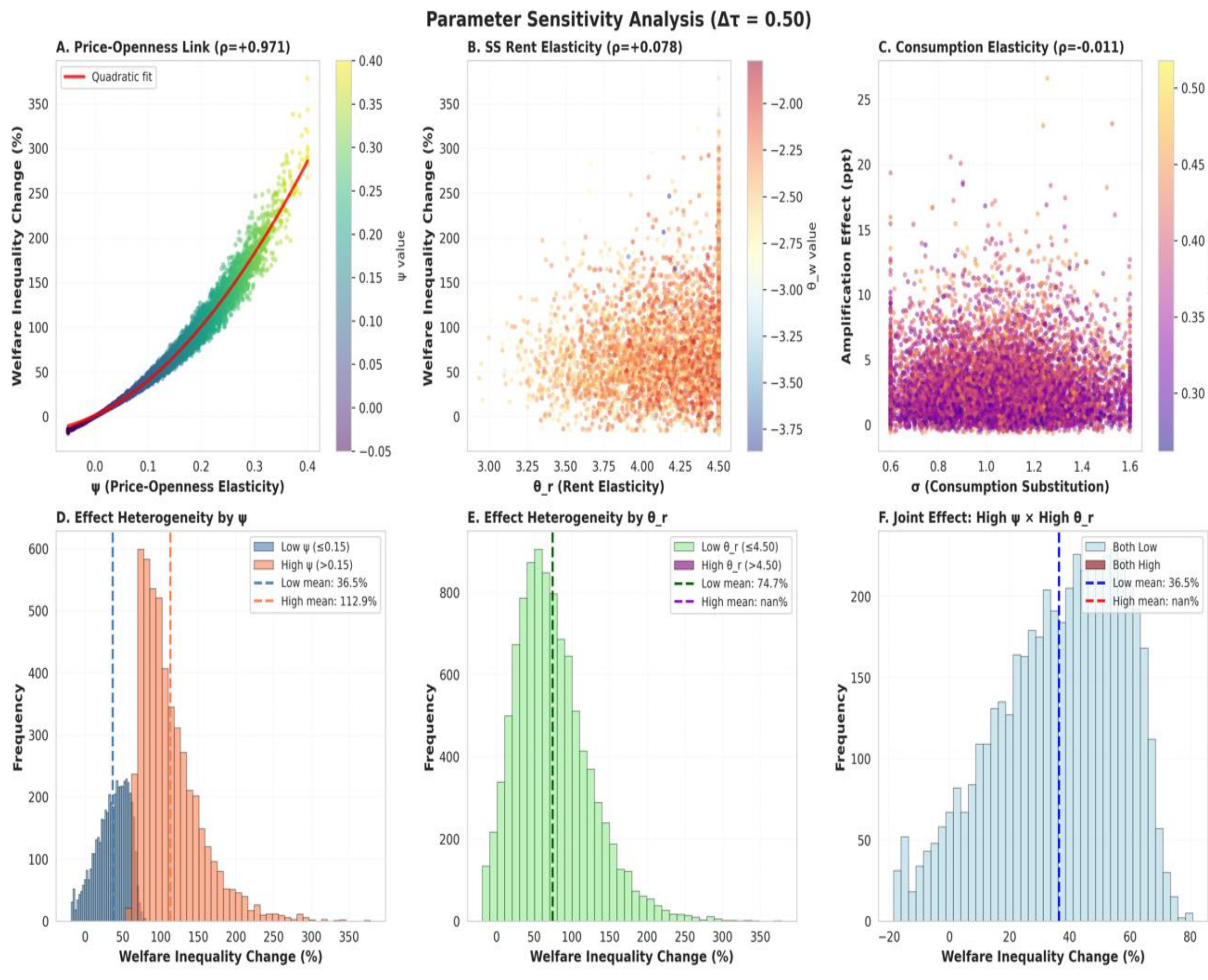

Figure 2 – Parameter Sensitivity Analysis (A) *Price-Openness Link (ρ=+0.971). Scatter plot of ψ versus welfare inequality (10,000 draws). Color intensity indicates ψ value. Red quadratic fit shows accelerating effects: ψ > 0.25 generates inequality increases exceeding 200%.* ***(B)*** *SS Rent Elasticity (ρ=+0.078). Scatter plot of* θ_r *versus welfare inequality, colored by* θ_w*.* ***(C)*** *Consumption Elasticity (ρ=-0.011). Scatter plot of σ versus amplification effect, colored by* α_L*.* ***(D)*** *Effect Heterogeneity by ψ. Histograms comparing low-ψ (≤0.15, blue) versus high-ψ (>0.15, orange) scenarios.* ***(E)*** *Effect Heterogeneity by* θ_r*. Histograms comparing low* θ_r *(≤4.50, green) versus high* θ_r *(>4.50, purple) scenarios.* ***(F)*** *Joint Effect: High ψ × High* θ_r*. Histogram comparing "both low" (blue) versus "both high" (red) scenarios.*

Price-openness elasticity (ψ) emerges as the dominant driver of outcomes. Panel A reveals a strong positive correlation (ρ = +0.971) between ***ψ*** and welfare inequality change. The quadratic

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fit demonstrates accelerating effects: when $\boldsymbol{\psi} > 0.25$ (indicating strong tourism-agriculture price linkage), inequality increases can exceed 200% even under moderate integration. Panel D quantifies this heterogeneity by splitting the sample at the median $\boldsymbol{\psi}$ value: scenarios with high $\boldsymbol{\psi}$ (>0.15) generate mean inequality increase of 112.9%, while low $\boldsymbol{\psi}$ (≤0.15) scenarios average only 36.5%: a threefold difference. This finding has direct policy implications, as $\boldsymbol{\psi}$ is potentially malleable through agricultural productivity investments, import liberalization, or tourism sector diversification.

Rent elasticity (θ_r) exhibits weaker influence than theory might suggest. Panel B shows modest correlation (ρ = +0.078) with substantial scatter around the trend line. Panel E reveals that high θ_r scenarios (>4.5) produce mean inequality increase of 74.7%, while low θ_r (≤4.5) generates nearly identical outcomes (74.7% mean). This insensitivity occurs because within the structurally derived parameter space, high θ_r tends to coincide with high land cost share (s_T), which partially offsets the distributional impact by reducing the labor share exposed to wage suppression. This suggests that policies targeting production structure may be less effective than policies targeting price linkages.

Consumption elasticity (σ) has minimal impact on the amplification mechanism. Panel C shows near-zero correlation (ρ = -0.011) between σ and the amplification effect. While lower σ theoretically increases cost-of-living impacts (workers are less able to substitute toward cheaper goods), the effect is quantitatively modest in the empirically relevant range [0.6, 1.6]. Mean amplification remains approximately 2.9 percentage points across the σ distribution. This finding suggests that consumption-side interventions (e.g., improving access to substitute goods) are unlikely to substantially mitigate the amplification effect.

Joint parameter effects reveal compounding mechanisms. Panel F demonstrates that when both $\boldsymbol{\psi}$ and θ_r are simultaneously high, inequality effects compound dramatically. The "both high" scenario ($\boldsymbol{\psi} > 0.15$ and $\theta_r > 3.5$) generates distributional outcomes in the right tail of the overall distribution, while "both low" scenarios cluster in the left tail. This interaction effect is economically intuitive: strong price transmission (high $\boldsymbol{\psi}$) combined with rigid production technology (high θ_r) maximizes factor price responses, while the reverse combination minimizes them.

The sensitivity analysis points toward a clear policy hierarchy. First-order priority should attach to interventions that reduce $\boldsymbol{\psi}$ (the tourism-agriculture price linkage), as this parameter exhibits both high sensitivity and potential policy malleability. Second-order priority might target the joint distribution, even if θ_r cannot be directly reduced, ensuring it does not coincide with high $\boldsymbol{\psi}$ could moderate outcomes. Consumption-side interventions appear least promising given the weak σ sensitivity.

International Journal of Social Science and Economic Research

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4.3 Amplification Effect Analysis

Understanding the relative importance of nominal income effects versus cost-of-living amplification is essential for both theoretical interpretation and policy design. Figure 3 decomposes these mechanisms across the range of integration intensities.

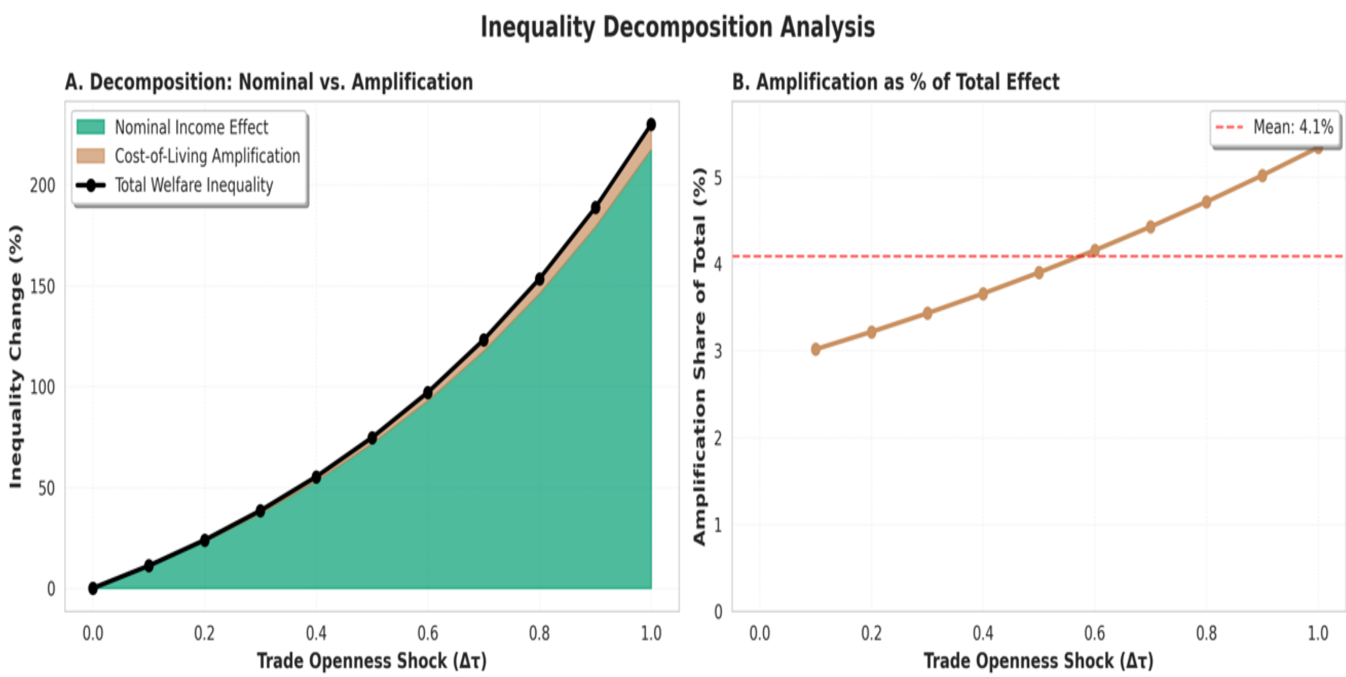

Figure 3 – Inequality Decomposition Analysis(A) *Nominal vs. Amplification. Stacked area chart decomposing total welfare inequality into nominal income effects (green) and cost-of-living amplification (brown). Black line shows total welfare inequality.* ***(B)*** *Amplification as % of Total Effect. Amplification as percentage of total welfare inequality change. Stable around 4.1% (red dashed line) across Δτ range, indicating proportional scaling of both nominal and amplification channels.*

Panel A illustrates that nominal income effects (green area) constitute the dominant component of inequality change throughout the integration range. At the baseline shock (Δτ = 0.5), nominal effects contribute 71.8 percentage points to the total 74.7% inequality increase, while cost-of-living amplification (brown area) adds 2.9 percentage points. The visual representation makes clear that the amplification effect, while theoretically important, operates as a secondary mechanism that compounds rather than drives distributional outcomes. The total effect (solid black line) tracks closely with the upper boundary of the stacked areas, indicating minimal interaction between the two channels beyond simple addition.

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Panel B quantifies the relative importance more precisely. The amplification shares averages 4.1% of the total inequality effect and exhibits remarkable stability across $\Delta\tau$ values, ranging only from 3.0% at $\Delta\tau$ = 0.1 to 5.2% at $\Delta\tau$ = 1.0. This stability indicates that both nominal and amplification effects scale proportionally with integration intensity, rather than one channel dominating at extreme values.

Three observations regarding the quantitative importance. First, the amplification effect is consistently positive: in 96.9% of scenarios, welfare inequality exceeds nominal inequality. This universality distinguishes it from a mere statistical artifact as it represents a systematic feature of the model's mechanics. Second, despite its modest magnitude relative to Stolper-Samuelson effects, the amplification is policy-invisible under conventional measurement. From a policy monitoring perspective, authorities observing wage data would underestimate true welfare divergence by approximately 4%, a gap that compounds over time and could accumulate to substantial welfare losses across affected populations. Third, the effect is mechanically regressive. It harms precisely those with higher agricultural expenditure shares, who are typically lower-income workers already experiencing wage declines through Stolper-Samuelson channels.

5. Discussions

5.1 Interpretation of Results

The Monte Carlo simulations reveal three central findings about trade openness and welfare inequality in tourism-dependent economies. First, the distributional consequences are substantial and asymmetric: a moderate trade shock ($\Delta\tau$ = 0.5) increases welfare inequality by 75% on average, with workers losing 18% of real income while landowners gain 39%. These magnitudes are economically significant: comparable to observed inequality increases following major trade liberalizations in developing economies (Goldberg and Pavcnik, 2007; Topalova, 2010). The near-certainty of adverse worker outcomes (96.9% probability of losses) indicates that distributional costs are robust features rather than parameter specific artifacts.

Second, cost-of-living differentials systematically amplify nominal income inequality. Welfare inequality exceeds nominal inequality by 2.9 percentage points on average, with positive amplification occurring in 97% of scenarios. While quantitatively modest relative to Stolper-Samuelson factor price effects (constituting approximately 4% of total inequality change), this amplification represents a hidden tax on workers that is invisible to policymakers monitoring only income data. The systematic nature of this bias distinguishes it from a statistical artifact and establishes it as a fundamental feature of trade-induced structural change when consumption patterns differ across groups.

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Third, the price-openness elasticity (ψ) emerges as the dominant policy-relevant parameter, exhibiting threefold variation in outcomes between low-ψ (36.5% inequality increase) and high-ψ (112.9% inequality increase) scenarios. This sensitivity identifies price transmission mechanisms as the primary leverage point for policy intervention, while traditional production structure parameters (θ_r, θ_w) and consumption elasticities (σ) show surprisingly weak influence on distributional outcomes within empirically plausible ranges.

5.2 Relationship to Existing Literature

This paper extends several strands of the trade and inequality literature. The theoretical framework builds on Stolper and Samuelson (1941) and subsequent refinements by Jones (1965, 1971), but incorporates heterogeneous consumption preferences following the insight of Deaton (1989) that relative price changes have distributional consequences through consumption channels. While previous work has examined nominal income inequality from trade (Goldberg and Pavcnik, 2007; Helpman et al., 2017), the systematic integration of cost-of-living differentials distinguishes this analysis from standard treatments.

The finding that cost-of-living effects amplify rather than dampen nominal inequality contrasts with some urban economics literature where rich households disproportionately consume luxury services with rapid price growth (Moretti, 2013). The reversal occurs here because the expanding sector produces necessities with higher budget shares among workers. This highlights the importance of sector-specific context: trade effects on inequality depend critically on whether expanding sectors produce necessities or luxuries.

The quantitative approach relates to recent applications of Monte Carlo methods in trade economics (Costinot and Rodríguez-Clare, 2014; Caliendo and Parro, 2015). By fixing the policy shock and randomizing structural parameters, the analysis achieves causal identification while honestly reflecting parameter uncertainty, a middle ground between structural estimation and pure calibration exercises which understate uncertainty. The wide confidence intervals (95% CI: [-3%, 192%] for welfare inequality) represent genuine parameter uncertainty rather than simulation error, providing policymakers with realistic ranges rather than false precision.

The tourism-as-trade-shock framework extends work on service trade liberalization (Francois and Hoekman, 2010) by demonstrating that tourism generates factor market consequences identical to goods trade despite institutional differences. This suggests that distributional assessment tools developed for merchandise trade apply equally to service exports, a relevant insight given growing service shares in international trade flows.

The findings on parameter sensitivity relate to debates about the magnification property in Stolper-Samuelson models. While traditional theory emphasizes factor intensity parameters (s_T,

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ρ) and derived elasticities (θ_r, θ_w) as determinants of distributional outcomes, this analysis reveals that the price transmission mechanism (ψ), often treated as exogenous or assumed perfect, dominates empirical variation. This shifts policy focus from factor market rigidities to product market linkages, suggesting different intervention strategies than standard trade adjustment assistance.

Methodologically, the structurally derived parameter approach addresses a common critique of Monte Carlo analysis: that arbitrary parameter ranges generate arbitrary results. By deriving SS elasticities from primitives (s_T, ρ) rather than drawing them independently, the analysis ensures internal consistency while capturing uncertainty about underlying production technologies. The validation that 99.8% of draws satisfy the magnification property confirms that the parameter space excludes economically implausible regions while maintaining breadth.

The Jeju application contributes to understanding inequality in small, open, tourism-dependent economies, a context underrepresented in trade literature relative to manufacturing-focused liberalizations. Islands and coastal regions worldwide face similar structural characteristics including land scarcity, service specialization, limited import substitution, suggesting the findings may generalize beyond the specific Korean context. Future comparative work across tourism-dependent regions could test this conjecture.

5.3 Policy Considerations

The quantitative results suggest several considerations for managing distributional consequences of trade integration in tourism-dependent regions.

Traditional trade adjustment assistance focuses on nominal income losses through retraining programs, wage subsidies, and unemployment insurance. However, workers experiencing 18% real income loss face an additional 3 percentage point reduction through inflation differentials. A wage subsidy restoring nominal income to pre-shock levels leaves workers approximately 3% worse off in real terms. While this gap may appear modest, it compounds over time: sustained for a decade, this represents a 30% reduction in lifetime consumption opportunities. Effective compensation requires either (i) explicit cost-of-living adjustments indexed to group-specific consumption baskets, or (ii) direct transfers of agricultural goods (food stamps, housing vouchers) that bypass market price mechanisms. Current adjustment assistance programs in OECD countries rarely incorporate such provisions, suggesting systematic under-compensation of trade-displaced workers.

Sensitivity analysis identifies the price-openness elasticity (ψ) as the dominant determinant of distributional outcomes, with correlation ρ = +0.971 to welfare inequality. Reducing ψ from 0.20

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to 0.10 decreases mean welfare inequality from approximately 95% to 40% at $\Delta\tau = 0.5$ – a 55 percentage point reduction. Four mechanisms could reduce ψ:

Agricultural productivity enhancements that allow supply expansion without price increases: greenhouse technology, vertical farming, improved irrigation, mechanization, and higher-yielding crop varieties. If tourism-driven food demand can be met through quantity adjustments rather than price adjustments, ψ mechanically declines. For Jeju specifically, investments in citrus productivity and land reclamation could moderate price responses to tourism growth.

Selective import liberalization that caps local food prices by allowing mainland Korean or international competition. However, this approach faces trade-offs: it undermines agricultural employment and conflicts with local food branding that attracts tourists. Optimal policy likely involves targeted liberalization for staple goods while protecting differentiated local products.

Tourism sector diversification toward activities not competing for agricultural land –marine tourism, cultural heritage, digital infrastructure for remote workers, conference facilities. This allows tourism revenue growth without bidding up land prices or agricultural costs. Jeju's recent initiatives attracting technology workers align with this strategy, though scale remains modest.

Strict land-use zoning preventing agricultural land conversion to tourism uses. Regulatory separation mechanically reduces competition for land, lowering ψ. Enforcement challenges and political economy pressures limit effectiveness, but strengthened zoning with transparent criteria could meaningfully reduce price transmission.

Quantitatively, if agricultural subsidies costing 2-3% of regional GDP can reduce ψ by 50%, the intervention satisfies cost-benefit criteria given inequality reduction exceeding 50 percentage points.

The extreme asymmetry creates substantial scope for redistribution through progressive taxation. Land value taxation captures tourism-driven appreciation with minimal distortionary effects. A 20% land value tax extracts approximately 8 percentage points of landowner gains, sufficient to finance meaningful worker compensation. Progressive property taxation with rising marginal rates on high-value properties concentrates incidence on beneficiaries while exempting modest holdings. Tourism development levies – per-visitor taxes earmarked for resident compensation – provide precedent from other jurisdictions (Venice, Barcelona) facing similar pressures.

For Jeju specifically, the analysis suggests reconsidering the tourism-maximization development model. Rather than maximizing visitor arrivals (high $\Delta\tau$), policy could optimize for tourism quality with lower volumes but higher per-visitor spending. Maintaining $\Delta\tau \approx 0.3$ keeps welfare inequality increases below 50%, potentially manageable through modest redistribution programs.

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Beyond $\Delta\tau = 0.5$, inequality effects accelerate sharply (Panel D, Figure 1), suggesting diminishing returns to further integration. Concrete instruments include higher hotel standards requiring luxury accommodations, differential visa policies favoring long-stay visitors, marketing targeting affluent demographics, and limiting low-cost carrier expansion while accommodating premium carriers.

These considerations extend beyond Jeju to other tourism-dependent economies facing similar structural trade-offs between growth and equity. The near-universal amplification finding (97% of scenarios) suggests that cost-of-living channels warrant inclusion in ex-ante distributional assessments of tourism development strategies globally. Urban contexts experiencing gentrification face analogous mechanisms, where affluent newcomers bid up prices for location-specific goods, harming long-term residents through channels like those documented here.

The model-derived insights suggest policy priorities distinct from standard trade adjustment assistance. Rather than focusing exclusively on labor market interventions (retraining, wage insurance), effective policy requires simultaneous attention to product market linkages (reducing ψ) and redistribution mechanisms (capturing windfall gains for compensation). The quantitative magnitudes – particularly the threefold outcome variation across ψ regimes – indicate high returns to interventions targeting price transmission relative to interventions targeting labor mobility or production structure.

5.4 Limitations

Several limitations qualify the findings and suggest productive research directions. **First, parameter uncertainty generates wide confidence intervals** (95% CI: [-3%, 192%] for welfare inequality), limiting precise quantitative predictions. Future research estimating ψ, θ_r, θ_w econometrically from Jeju time-series data would substantially narrow these bounds. Required data include panel variation in agricultural prices, land rents, wages (2000-2024), tourism flows, and household consumption patterns by income group. Identification could exploit exogenous variation from exchange rate movements, international economic conditions, or transportation capacity constraints. Difference-in-differences comparing Jeju to similar non-tourism regions could provide additional leverage.

Second, the static framework abstracts from dynamic adjustments including capital accumulation, labor migration, and technological change. Long-run effects could differ substantially if workers migrate to mainland Korea, tourism investments increase agricultural productivity, or landowners invest gains in worker training. A dynamic extension would require specifying adjustment costs, migration decisions, and investment functions, substantially increasing model complexity but providing insights about transition paths versus steady states.

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Calibration would necessitate panel data covering multiple decades to distinguish adjustment speeds empirically.

Third, Jeju's extreme tourism dependence may limit generalizability. Applying the framework to other tourism regions (Bali, Mallorca, Maldives, Caribbean islands) would reveal whether the 4% amplification effect and strong ψ-sensitivity are universal or context-specific. Comparative analysis could test hypotheses that amplification scales with tourism intensity, land scarcity, consumption heterogeneity, and import substitution possibilities. Cross-regional variation provides natural experiments for testing model predictions.

Fourth, partial equilibrium holds manufacturing prices fixed (P_M = 1), abstracting from general equilibrium feedback where tourism growth might raise economy-wide wages, alter terms of trade, or induce structural transformation beyond agriculture. A computable general equilibrium model would capture these channels but requires specifying additional sectors, production functions, and closure rules. Both approaches have value: partial equilibrium for mechanism isolation, CGE for comprehensive policy evaluation.

Fifth, CES utility imposes unitary wealth effects and rules out necessity/luxury distinctions. Alternative specifications including Stone-Geary, AIDS, QUAIDS could generate different results if agricultural goods are inferior or if subsistence requirements bind for low-income workers. Robustness analysis with non-homothetic preferences would bound this concern, though data requirements increase substantially.

Sixth, endogenous liberalization is ignored. The analysis treats trade openness (Δτ) as exogenous, but liberalization pace is endogenously determined, often by benefiting groups. Extensions examining political economy could formalize why inequality-increasing integration proceeds despite distributional concerns through mechanisms including landowner political influence, median voter dynamics, growth-equity trade-offs, or incomplete information about distributional consequences.

Seventh, spatial heterogeneity within Jeju is suppressed. Coastal tourist zones likely experience different dynamics than interior agricultural zones, and mixed economies face distinct pressures. Spatial disaggregation would require detailed microdata on within-island variation and would need to model internal trade and migration. Such extension could identify zones most vulnerable to adverse outcomes, permitting geographically targeted interventions.

Future research addressing these limitations would strengthen both theoretical understanding and practical policy guidance for managing distributional consequences of structural transformation in small, open economies.

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6. Conclusion

This paper demonstrates that conventional trade models focusing exclusively on nominal income inequality substantially underestimate the welfare consequences of trade integration. Using a modified Stolper-Samuelson framework incorporating heterogeneous consumption patterns, the analysis reveals a "double burden" mechanism where trade openness simultaneously reduces worker wages through factor market adjustments and raises their cost-of-living through differential inflation exposure.

Applied to Jeju Island's tourism-driven integration, Monte Carlo simulations with 10,000 parameter draws quantify these effects. A baseline trade shock ($\Delta\tau = 0.5$) increases welfare inequality by 75% on average, with workers losing 18% of real income while landowners gain 39%. Cost-of-living differentials systematically amplify inequality by 2.9 percentage points beyond nominal effects present in 97% of scenarios. Though quantitatively modest relative to Stolper-Samuelson factor price changes (approximately 4% of total effect), this amplification is invisible to standard income-based inequality metrics and compounds worker disadvantage.

Parameter sensitivity analysis identifies the tourism-agriculture price linkage (ψ) as the dominant driver, with high-ψ scenarios ($\psi > 0.25$) generating inequality increases exceeding 200% versus below 50% for low-ψ scenarios ($\psi < 0.10$). This threefold variation suggests that policies moderating price transmission (agricultural productivity investments, selective import liberalization, tourism diversification, or land-use regulation) offer substantially higher returns for inequality reduction than interventions targeting production structure or consumption patterns.

The findings carry implications extending beyond Jeju to tourism-dependent economies globally and to urban contexts experiencing gentrification. The systematic nature of cost-of-living amplification, positive across 97% of the parameter space, indicates that welfare analysis of structural transformation must move beyond income-based metrics toward comprehensive measurement incorporating consumption possibilities. Statistical agencies should prioritize constructing group-specific price indices to capture real welfare changes during trade integration and structural change.

The wide confidence intervals (95% CI: [-3%, 192%] for welfare inequality) reflect genuine parameter uncertainty and highlight the need for future econometric estimation using panel data on prices, wages, and consumption patterns. Dynamic extensions incorporating migration, capital accumulation, and technological change would provide insights about long-run adjustments beyond the short-run static effects quantified here. Comparative analysis across multiple tourism-dependent regions would test whether the documented mechanisms represent universal features or context-specific outcomes.

As tourism-dependent regions worldwide navigate tensions between growth and equity, recognizing cost-of-living channels as systematic drivers of inequality transmission becomes essential for designing policies that genuinely protect vulnerable populations during structural change. Compensation mechanisms restoring only nominal income leave workers systematically worse off by approximately 4% in the Jeju application, creating hidden welfare losses that accumulate over time and undermine the political sustainability of trade integration.

Acknowledgements

The author declares no conflicts of interest. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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