Individual Labor Supply, Worker Skills, and Gains from Trade*

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Abstract

How does trade liberalization affect individuals' labor supply decisions, and what are the implications for welfare? This paper studies the intensive margin of labor supply — time allocated between market work and home production — in an open-economy framework. We develop a tractable labor-supply module in which workers of heterogeneous skill consume both a market-good composite and a home good, and show that real wages are a sufficient statistic for individual labor-supply decisions. When market goods and home production are substitutes, trade-induced wage gains raise hours worked, with the response diminishing in worker skill. Embedding this module in the Eaton-Kortum model, we derive a welfare formula that decomposes gains from trade into the standard ACR statistic and a labor-supply factor — the utility-weighted share of time devoted to market work. Using Taiwanese panel microdata and tariff concessions from the 2010 Economic Cooperation Framework Agreement (ECFA) as instruments, we find empirical support for the substitutability case: wages raise labor supply across all skill groups, with decreasing elasticity for higher-skilled workers. Quantitatively, the calibrated aggregate labor-supply rate averages 0.62 across countries, implying that welfare gains from trade are only 62% of those predicted by a model with inelastic labor supply. Omitting the intensive margin of individual labor supply substantially overstates the gains from trade.

Keywords: individual labor supply; home production; real wages; skill; welfare gains from trade; ECFA
JEL codes: F16; J22; F11

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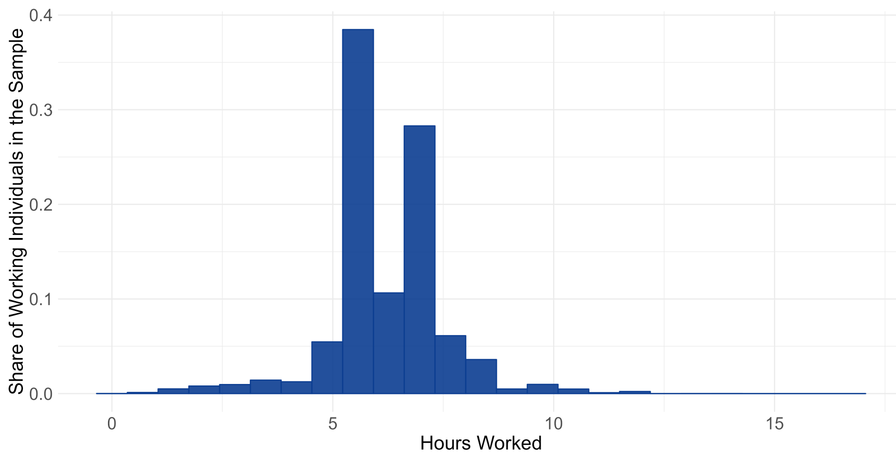
1 Introduction

How much do people choose to work, and how does trade shape that decision? These questions bear directly on individual and aggregate welfare, yet the international trade literature has devoted remarkably little attention to the intensive margin of labor supply — the number of hours an employed worker actually works. A large and growing body of research examines how trade reshapes workers' choices of occupation, sector, and location, but almost universally assumes that employed workers supply their labor inelastically. In practice, labor supply is neither fixed nor uniform: as Figure 1 illustrates using data from Taiwan's Manpower Utilization Survey, there is substantial dispersion in hours worked even among employed individuals. Understanding how trade affects this margin — and why it varies so markedly across workers — is the central question of this paper.

We address this question through a unified theoretical, empirical, and quantitative analysis. On the theory side, we develop a model of workers' time allocation between market employment and home production — activities such as child-rearing, housework, elderly care, and leisure. Workers are heterogeneous in skill, which determines both their market wage and the opportunity cost of time spent at home. The key prediction is simple: when market goods and home production are substitutes, a rise in real wages induces workers to shift time toward the market, increasing hours worked. When they are complements, the opposite holds. Crucially, this labor-supply response varies with skill: higher-skilled workers — who already work longer hours — adjust less at the margin. The framework is highly tractable: individual labor supply, income, and welfare all depend on aggregate market conditions solely through the real wage, making the module easy to embed in any standard trade model.

We test these predictions using rich individual-level data from Taiwan's Manpower Utilization Survey, covering the period 2007–2017. Taiwan provides a suitable setting for this analysis: the survey covers detailed individual-level information on labor supply, wages, and worker characteristics, and the period coincides with a major bilateral trade policy event. In particular, the 2010 Economic Cooperation Framework Agreement (ECFA) with China — Taiwan's largest trading partner overall during the period — introduced tariff concessions driven by geopolitical considerations between the two economies, which we use as instruments for the local wages workers face. Our estimates show that higher potential wages significantly increase individual hours worked, with the elasticity decreasing in workers' years of schooling. Both findings align with our theoretical predictions under

Figure 1: Distribution of Hours Worked in Taiwan's Manpower Utilization Survey



the substitutability case: trade liberalization raises labor supply, and does so most strongly among lower-skilled workers.

We show that this labor-supply channel has first-order implications for the welfare gains from trade. The canonical framework of Arkolakis, Costinot and Rodríguez-Clare (2012) (ACR) — which underlies much of the modern quantitative trade literature — assumes inelastic labor supply. We embed our labor-supply module into the Eaton and Kortum (2002) Ricardian trade model, which belongs to this class, and show that welfare gains from trade decompose into two terms: the standard ACR statistic, which captures gains through cheaper market goods, and a labor-supply factor, which reflects the share of time workers devote to the market. Because workers allocate a substantial fraction of their time to home production, this factor is meaningfully below one — averaging 0.62 across countries in our calibration. The implication is stark: accounting for endogenous labor supply reduces estimated welfare gains from trade to roughly 62% of those predicted by the standard model. Far from being a technical refinement, the intensive margin of labor supply is a quantitatively important moderator of the gains from trade.

The labor-supply module we develop is not specific to the Eaton-Kortum framework: because individual labor supply and welfare depend on aggregate conditions solely through the real wage, the module can be embedded in any trade model where real wages are well defined. This portability suggests that the moderating effect of endogenous labor supply we document — roughly 38% of the standard welfare gains — may extend broadly across the quantitative trade literature.

Literature Review

The literature on trade and labor market outcomes has deepened our understanding of workers' choices across occupations, sectors, locations, and employment status — all distinct extensive margins of aggregate labor supply. See, for example, Artuç et al. (2010), Artuç and McLaren (2015), Lee and Yi (2018), Tombe and Zhu (2019), Caliendo et al. (2019), Traiberman (2019), He (2019), Lee (2020), and Adão et al. (2026). By assuming inelastic individual labor supply, however, these studies abstract from intensive-margin adjustments at the individual worker level. This paper contributes to the trade-labor nexus literature by examining the intensive margin of labor supply.

Our modeling of the intensive margin connects to a closed-economy macro literature that treats nonmarket time as home production rather than leisure only. Aguiar et al. (2013) establish that when working time falls, a sizeable share of the released time is reallocated to home production rather than leisure; a strand of this literature uses the home-production margin to discipline the preference parameters governing labor-supply responses (McGrattan et al., 1997; Rogerson and Wallenius, 2016). Boerma and Karabarbounis (2021) further show that differences in home production efficiency across households amplify inequality in welfare.[1]

Our work also engages the literature on welfare gains from trade. Arkolakis et al. (2012) established a benchmark in which the gains depend on the domestic expenditure share and the trade elasticity, and a large subsequent literature has explored new margins that generate departures from this formula.[2] The ACR class treats labor supply as inelastic as a maintained assumption; our analysis shows that relaxing this assumption matters quantitatively for welfare at both the aggregate and individual levels.

Within this landscape, the two most closely related papers are Kim and Vogel (2021) and Velasquez (2025). Kim and Vogel (2021) allow labor-market adjustment to occur through hours worked alongside labor-force participation, unemployment, and sectoral search in a theoretical framework of trade shocks, extending the Stolper-Samuelson logic to these margins. Our paper complements this by deriving theoretical predictions on how trade affects

[1] See also Blundell et al. (2011), Chetty et al. (2011), and Attanasio et al. (2018) on how aggregate labor supply responds to shocks through both participation and hours; and Chang and Schorfheide (2003) and Rupert et al. (2000) for additional macro models incorporating home production.

[2] For example, see Edmond et al. (2015), Feenstra and Weinstein (2017), Arkolakis et al. (2019), Hsu et al. (2020) for the role of variable markups; see Costinot and Rodríguez-Clare (2014) and Ossa (2015) for the role of multiple sectors and heterogeneous trade elasticities; see Caliendo and Parro (2015) for the roles of intermediate goods and sectoral linkages; see Melitz and Redding (2015) for the role of productivity distribution; see Sampson (2016), Ravikumar et al. (2019), Buera and Oberfield (2019), Perla et al. (2021), Hsieh et al. (2021), and Hsu et al. (2024) for the role of dynamics; see Baqaee and Farhi (2024) for the role of production networks; and see Fieler and Eaton (2025) for the role of the quality margin.

individual labor supply and showing that the response depends on the elasticity of substitution between market and home goods and on skill level. Velasquez (2025) embeds a representative household's choice between work and leisure in an Eaton-Kortum environment and shows that higher real income from trade induces households to work fewer hours. Our paper also emphasizes the real-wage channel but models nonmarket time as home production rather than leisure and allows labor-supply responses to vary across workers — distinctions that change both the mechanism and the welfare implications of trade, as responses depend on market-home substitutability and feed back into the measurement of gains from trade. We further complement both studies with empirical and quantitative analyses that document the heterogeneity of these responses across skill levels.

The rest of the paper is organized as follows. Section 2 presents a labor-supply module to analyze workers' labor-supply decisions. Section 3 presents the empirical evidence for the key theoretical predictions of the module. Section 4 embeds the labor-supply module into the Eaton-Kortum model and derives the formula for welfare gains from trade. Section 5 quantifies the model and conducts a quantitative analysis of gains from trade. Section 6 concludes.

2 A Labor Supply Model

This section presents a simple model of labor supply and illustrates how differently skilled workers differ in their labor supply.

2.1 Model

There is a mass L of workers whose preferences are given by the following utility function:

$$U = \left[\theta C^{\frac{\epsilon-1}{\epsilon}} + (1-\theta)\, c_h^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}$$

$$C \equiv \left(\int_{\omega\in\Omega} c(\omega)^{\frac{\sigma-1}{\sigma}}\, d\omega\right)^{\frac{\sigma}{\sigma-1}},$$

where Ω denotes the set of "market goods", $c(\omega)$ is the consumption of a market good ω, σ is the elasticity of substitution among market goods, c_h is the consumption of the "home good", $\theta \in (0,1)$ denotes the weight on market-good consumption, and $\epsilon > 0$ denotes the elasticity of substitution between market and home goods. The home good is produced at home and includes non-market activities such as child-rearing, housework, elderly care, and leisure.

Each worker is endowed with $\bar{n}$ units of time, which is allocated between working in the labor market and performing home production. Workers differ in their skill levels $z \in \mathbb{R}^{+}$, which can also be interpreted as efficiency units of their labor supply. The labor market is perfectly competitive, and the wage rate for one efficiency unit of labor is denoted as w. We denote a worker's labor supply rate, i.e., the fraction of time allocated to working in the labor market, by $r \in [0,1]$. Hence, the earned income for a worker with skill level z is $\bar{n}rwz$. For each (raw) unit of time that the workers spend on home production, one unit of the home good is produced.

The worker's budget constraint is given by

$$\int_{\omega\in\Omega} p(\omega)\, c(\omega)\, d\omega = \bar{n}rwz \equiv y \tag{1}$$

$$c_h = (1-r)\,\bar{n}, \tag{2}$$

where y is the income of a worker given his/her skill level z. The utility maximization problem yields the following solutions:

$$r(z) = \frac{\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}z\right)^{\epsilon-1}}{1+\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}z\right)^{\epsilon-1}} \tag{3}$$

$$y(z) = \bar{n}\frac{\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}z\right)^{\epsilon-1} wz}{1+\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}z\right)^{\epsilon-1}} \tag{4}$$

$$C(z) = \frac{y(z)}{P} = \bar{n}\frac{\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}z\right)^{\epsilon-1} \frac{w}{P}z}{1+\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}z\right)^{\epsilon-1}} \tag{5}$$

$$c_h(z) = (1-r)\,\bar{n} = \frac{\bar{n}}{1+\left(\frac{\theta}{1-\theta}\right)\left(\frac{w}{P}z\right)^{\epsilon-1}}, \tag{6}$$

where P denotes the CES price index

$$P = \left(\int_{\omega\in\Omega} p(\omega)^{1-\sigma}\, d\omega\right)^{\frac{1}{1-\sigma}}. \tag{7}$$

Note that the real variables of interest, C, c_h, and r, are affected by "market signals" only through the real wages w/P. All of these variables, as well as the nominal income y, are functions of skill level z.

The indirect utility of a worker with skill level z is given by

$$V\left(z;\frac{w}{P}\right)=\bar{n}\,(1-\theta)^{\frac{\epsilon}{\epsilon-1}}\left[1-r\left(z;\frac{w}{P}\right)\right]^{-\frac{1}{\epsilon-1}}. \tag{8}$$

Interestingly, labor supply rate r is a sufficient statistic for a worker's indirect utility, as it absorbs information about skill level z and real wage rate w/P.

An increase in the real wage rate w/P or the skill level z leads to a substitution effect toward the market goods, and induces workers to increase labor supply (and hence earned income) for purchasing the market goods. However, this also induces an income effect that raises the demand for both goods. As a result, the consumption of market goods C will necessarily increase with w/P or z, while the consumption of home good c_h and labor supply rate r may increase or decrease conditional on the elasticity of substitution ϵ. When the home good and the market goods are substitutes ($\epsilon > 1$), the substitution effect dominates such that c_h decreases and r increases given higher w/P or z. In contrast, when the home good and the market goods are complements ($\epsilon < 1$), the income effect dominates such that c_h increases and r decreases. The following proposition formally summarizes these mechanisms.

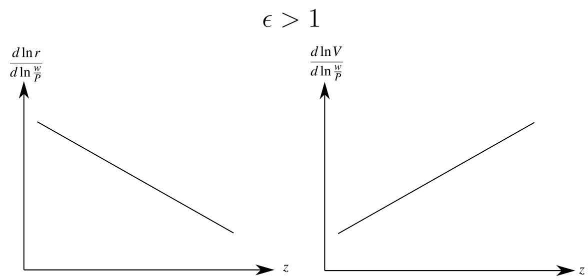
Proposition 1. *Given higher real wage rate w/P or higher skill level z,*

1. *a worker's consumption of market goods C will necessarily increase;*
2. *the labor-supply rate r will increase while the consumption of home good c_h will decrease if $\epsilon > 1$; the opposite is true if $\epsilon < 1$;*
3. *a worker's utility level V will be higher; moreover, V depends on w/P or z only through the labor-supply rate r.*

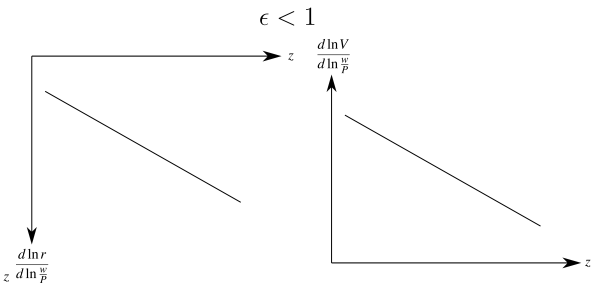
Proof. Proposition 1.1 and 1.2 can be obtained by inspecting Equations (3), (5), and (6). Equation (8) indicates that V depends on w/P or z only through the labor supply rate r. For either case where $\epsilon > 1$ or $\epsilon < 1$, it can be shown that V increases with w/P or z, by using Equation (8) and Proposition 1.2. □

Proposition 1 implies that the supply-side fundamentals for the market goods (e.g., trade shocks or productivity growth) will affect workers' labor supply rate and welfare

Figure 2: Elasticities of Labor Supply Rate and Utility to Real Wages



(a) $\epsilon > 1$



(b) $\epsilon < 1$

only through their effects on the real wages w/P. Thus, the labor supply model proposed above can be embedded in any general equilibrium models in which a price index P summarizes the prices of market goods and the labor markets are perfectly competitive.[3] From the viewpoint of the trade literature, most (but not all) scenarios of trade liberalization lead to an increase in w/P, and in such a case, Proposition 1 can be applied to predict the effect of trade liberalization on labor supply and welfare. In particular, trade liberalization leads to increases in labor supply if $\epsilon > 1$. Otherwise, it leads to decreases in labor supply.

We next analyze how changes in real wages may affect labor supply and welfare differentially across differently skilled workers. The findings are summarized in Proposition 2 and illustrated in Figure 2.

Proposition 2. *The elasticity of worker utility to real wages, $d\ln V/d\ln(w/P)$, equals the labor-supply rate r. Moreover,*

1. *when $\epsilon > 1$, the elasticity of labor supply rate to real wages, $d\ln r/d\ln(w/P)$, is positive and decreases in worker skill z, while $d\ln V/d\ln(w/P)$ is positive and increases in z;*

2. *when $\epsilon < 1$, the elasticity of labor supply rate to real wages, $d\ln r/d\ln(w/P)$, is negative and decreases in worker skill z, while $d\ln V/d\ln(w/P)$ is positive and decreases in z.*

Proof. See Appendix A.1. □

To understand the intuition, first recall that the labor-supply rate r is a 1-to-1 mapping of the home-good consumption c_h by the relation: $c_h = (1-r)\bar{n}$. If the real wage rate w/P increases, in the case of $\epsilon > 1$, the substitution effect dominates the income effect such that c_h decreases and r increases. A higher skill level turns the same working time into

[3]Note that, even when the labor markets are not perfectly competitive so that the wage rate for an efficiency unit w is not independent of z, Proposition 1 still holds for the z-specific real wage w_z/P.

higher income and higher market-good consumption, but convex preferences imply that the higher-skilled workers would like to mitigate the reductions in home-good consumption/production. Thus, the elasticity of $d\ln r/d\ln(w/P)$ is lower for higher-skilled workers. In the case of $\epsilon < 1$ so that the two goods are complements, the income effect dominates the substitution effect such that c_h increases and r decreases. Again, a higher skill level turns the same working time into higher income and higher market-good consumption, but in this case, the complementarity between the two goods induces more home-good consumption/production for higher-skilled workers. Thus, the labor-supply rate is reduced by more for higher-skilled workers.

Proposition 2 also shows that the welfare elasticity of a worker is exactly his/her labor supply rate. Consider an increase in the real wage rate due to reductions in trade costs. This finding implies that workers with higher labor supply rates experience greater welfare gains from trade in percentage terms. The intuition is that a higher labor supply rate r means that the market-good consumption accounts for a larger portion of the worker's utility, and hence, such a worker's utility is more sensitive to trade shocks (or any shock that affects real wages). In the case where $\epsilon > 1$, a worker's utility is more sensitive to shocks in real wages if the worker is higher-skilled. The opposite pattern is true when $\epsilon < 1$.

2.2 ***Aggregation***

We assume that the workers' skill levels follow a Pareto distribution such that the cumulative density function is given by:

$$H(z) = 1 - z^{-\kappa_z}$$

with the support $z \in [1, \infty)$ and a tail index $\kappa_z > 1$. As there is a continuum of heterogeneous workers with mass L, the aggregate income is given by $Y \equiv L \int_z y(z)\, dH(z)$, and the average labor-supply rate is given by $R \equiv \int_z r(z)\, dH(z)$. Note that the preferences here are not homothetic because consumers can only spend their income on the market goods, but not the home good. Therefore, there is no representative consumer, and the aggregate welfare depends on how a social welfare function is specified. We assume a Benthamite social welfare function, and thus the aggregate welfare is given by integrating utility over the workers:

$$W = LE_z(V(z)) \tag{9}$$
$$= \bar{n}(1-\theta)^{\frac{\epsilon}{\epsilon-1}} LE_z\left[\left(1-r\left(z;\frac{w}{P}\right)\right)^{-\frac{1}{\epsilon-1}}\right].$$

Since Propositions 1 and 2 imply that the labor-supply rate and utility for each worker are all monotonic in w/P, we expect that the aggregate variables, Y, R, and W, are also monotonic in w/P. The following lemma shows that these aggregate variables, defined as integrals, converge when worker skill z follows a Pareto distribution.

Lemma 3. *Suppose that z follows a Pareto distribution, $H(z) = 1 - z^{-\kappa_z}$, where $z \in [1, \infty)$ and $\kappa_z > 1$. Then, the aggregate welfare, W, the aggregate income, Y, and the average labor-supply rate, R, defined as integrals over the support $z \in [1, \infty)$, converge. The aggregate welfare W increases in real wages w/P for all $\epsilon > 0$. The average labor-supply rate R increases in w/P when $\epsilon > 1$ and decreases in w/P when $\epsilon < 1$.*

Proof. Appendix A.2 shows that these aggregate/average variables converge. The second part of the lemma follows directly from Proposition 2. □

3 Empirical Evidence

In this section, we assess the empirical validity of the theoretical predictions proposed in Section 2. As an overview, we find that the elasticity of the labor-supply rate is positive with respect to potential wage, and the elasticity decreases with the ability level of the individual. These findings are consistent with the theoretical predictions under the scenario where the market goods and the home good are substitutes ($\epsilon > 1$).

We conduct the analysis based on the Taiwanese individual survey data, "Manpower Utilization Survey," reported by the Taiwanese Directorate General of Budget, Accounting, and Statistics (DGBAS). The survey is conducted annually, with repeated sampling in each year (and hence is not a panel dataset), with a stratified two-stage sampling method to represent the Taiwanese demographics across locations. We use the data for the period 2007–2017, during which the items of the survey and variables of our interests are relatively harmonized (or can be harmonized) across surveys.

The Manpower Utilization Survey samples all members above age 15 in the surveyed households, and provides detailed information on education attainment, labor market participation and outcome, individual and household characteristics, and the sampling weight of each observation. The survey includes around 27,000 observations (individuals) in each year.

3.1 Measurement and Controls

We use individuals as the unit of analysis for the labor-supply rate. For each individual observed in the survey in each year, we calculate the labor-supply rate as the ratio of reported working hours relative to 24 hours. We measure the potential wage an individual faces (w in Equation 3) by the year-specific average wage of the county-sector in which the individual works in the year. The year-specific average wage of a county-sector is, in turn, calculated by the total wage income (monthly) of a county-sector in a year divided by the total number of individuals occupied in the county-sector pair in the year (taking into account the sampling weight for each observation). As a robustness check, we also consider the potential wage adjusted for working hours. That is, the average wage is measured by the total wage income (monthly) of a county-sector pair in a year divided by the total working hours (daily) of individuals occupied in the county-sector pair in the year (again, taking into account sampling weights). The choice of measuring the potential wage at the county-sector level (rather than an economy-wide wage) is in view of potential labor market frictions across counties and sectors that are not captured in the theoretical model.

We use years of schooling to measure the skill level of an individual. The observed years of schooling correspond to typical milestones of education attainments: 0 (no formal schooling); 6 (primary school); 9 (junior high school); 12 (senior high school or vocational school); 14 (junior high school + 5-year college; or vocational school + 2-year college); 16 (university); 18 (master's degree); and 22 (doctorate).

Guided by Proposition 2 and Equation (3), we use the following empirical specification to estimate the interaction between the potential wage ($\ln w$) faced by an individual and the ability (z) of the individual in influencing his/her labor market supply rate ($\ln r$):

$$\ln r_{icst} = \beta_w \ln w_{cst} + \beta_{wz} (\ln w_{cst} * z_{icst}) + \beta_z z_{icst} + X_{icst} \boldsymbol{\beta}_x + \lambda_{ct} + \delta_{st} + \varepsilon_{icst}, \tag{10}$$

where $\ln r_{icst}$ is the labor market supply rate (in logs) of individual i, who is located in county c and engaged in sector s, in year t; $\ln w_{cst}$ is the potential wage (in logs) faced by individuals located in county c and engaged in sector s, in year t; z_{icst} is the skill level of the individual i in year t; and X_{icst} is a list of household, individual, and workplace characteristics that could

Table 1: Definitions of variables used in empirical analysis

Variables	Definitions
labor supply rate (r_{icst})	the ratio of reported working hours per day relative to 24 hours a day by individual *i*, who is located in county *c* and engaged in sector *s*, in year *t*; the working hours reported in the data are weekly; we divide them by 7 to convert them to daily working hours
mean wage income (w_{cst})	the weighted average wage income of individuals in county-sector-year *cst*: measured by the total wage income (monthly) of a county-sector in a year divided by the total number of individuals occupied in the county-sector pair in the year (taking into account the sampling weight for each observation); in US dollars
mean wage rate (w_{cst})	the weighted average wage rate of individuals in county-sector-year *cst*; measured by the total wage income (monthly) of a county-sector in a year divided by the total working hours (daily) of individuals occupied in the county-sector pair in the year (taking into account sampling weights); in US dollars
years of schooling (z_{icst})	years of schooling attained by individual *i*, who is located in county *c* and engaged in sector *s*, in year *t*
nomem	the number of members in the household that the individual belongs to (including children under age 15)
shr20less	the share of members under age 20, in the household that the individual belongs to
shr65abv	share of members above age 65, in the household that the individual belongs to
shrjob	the share of members with jobs, in the household that the individual belongs to
shrmale	the share of members that are male, in the household that the individual belongs to
gender	the gender of the individual: 1. female; 2. male
age	the age of the individual
age_sq	the age squared of the individual
marriage	the marriage status of the individual: 1. divorced; 2. married; 3. single; 4. widowed
firmsize	the number of employees in the firm that the individual works for: 0. NA; 1. 1; 2. 2-9; 3. 10-29; 4. 30-49; 5. 50-99; 6. 100-199; 7. 200-499; 8. 500 and above; 9. the government
worktype	the type of employment: 1. employee; 2. employer; 3. self-employed; 4. unpaid family worker
workexp	months that the individual has been working for the current firm
year (t)	2007–2017
county (c)	20 counties/cities observed in the sample
sector (s)	32 ROCSIC Rev9 2-digit sectors in Primary/Manufacturing
$\ln \tau_{jt}$	one plus the tariff rate at the ROCSIC Rev9 4-digit level (in logs); *j* at the ROCSIC Rev9 4-digit level
$\ln \tau_{st}$, for *s* in Agriculture	three variations on how the 4-digit level tariff rates for Agriculture sectors (for which 4-digit employment data are not available) are aggregated to the 2-digit sector level, based on: (1) weighted average by initial year (2007) import values; (2) weighted average by current year import values; (3) simple average
tariff exposure ($\ln \tau_{cst}$)	$\ln \tau_{cst} \equiv \sum_{j \in s} \frac{L_{cjt}}{L_{jt}} \ln \tau_{jt}$ for *s* in Mining/Manufacturing sectors, and $\ln \tau_{cst} \equiv \frac{L_{cst}}{L_{st}} \ln \tau_{st}$ for *s* in Agriculture sectors. We consider a county-sector-year's tariff exposures due to: the tariffs levied by Taiwan ($\ln \tau_{cst,TW}$) against imports from China, and the tariffs levied by China ($\ln \tau_{cst,CN}$) against imports from Taiwan, respectively.

affect an individual's labor supply rate. These include: (i) the number of members, the share of members under age 20, the share of members above age 65, the share of members with jobs, and the share of members that are male, in the household that the individual belongs to; (ii) the gender, the age profile (age and age squared), and the marriage status, of the individual; and (iii) the firm size (in terms of the number of employees), the employment type (as employees, as employers, self-employed, or as unpaid family workers), and the job duration of the individual with the current firm in year *t*. The detailed definitions of these variables are provided in Table 1.

In all estimations, we also control for two sets of fixed effects (FE). These are: (i) county-year FEs (λ_{ct}) for 20 counties and years 2007, 2008, ..., 2017; and (ii) sector-year FEs (δ_{st}) for sectors at the ROCSIC Rev9 2-digit level (at which the manpower survey's industry/sector classification is reported) and years 2007, 2008, ..., 2017. The counties are classified by the latest demarcation of counties and major cities in Taiwan. During 2007–2017, some counties were merged with neighboring major cities (e.g., Tainan County with Tainan City) or renamed (e.g., Taoyuan County renamed as Taoyuan City). We harmonize these differences across years to reflect the latest classification.

To address potential endogeneity concerns that some omitted variables may simultaneously affect the labor-supply rate at the individual level and the market potential wage at the county-sector level, we construct instruments for the potential wage $\ln w_{cst}$ of a county-sector-year based on the county-sector-year's exposure to import tariffs levied by Taiwan and China against each other. This is in view of the heavy reliance of Taiwan on China as its major trading partner during the period of study,[4] and the meaningful shocks to the bilateral tariff rates introduced by the Economic Cooperation Framework Agreement (ECFA) signed by the two economies in 2010.

In particular, given the Taiwanese import tariffs compiled at ROCSIC Rev9 4-digit level, we use the information on county employment share (relative to the whole economy in the same sector) at the 4-digit level as weights to aggregate tariffs at the 4-digit level to construct the county-sector tariff exposure at the 2-digit sector level (at which the Manpower Utilization Survey data's industry/sector classification is observed). The county employment share (relative to the whole economy in the same sector) at the 4-digit level is sourced from the *Industry, Commerce and Service Census of Taiwan*, which has been conducted for firms in Mining, Manufacturing, and Services every 5 years (excluding Agriculture). We use the lagged (fixed at year 2001) county employment share as weights, to reduce the potential endogeneity of the constructed tariff exposure measures. For Agriculture sectors, for which 4-digit employment data are not available, we first aggregate 4-digit sectoral tariffs to the 2-digit sector level, and use the manpower survey data (of year 2000) on 2-digit county-sector employment share (relative to the whole economy in the same sector) as weights to measure the county-sector's tariff exposure. We consider 3 variations on how the 4-digit level tariff rates for Agriculture sectors are aggregated to the 2-digit sector level, based on:

[4]During this period, China was the largest export destination and the second largest import origin, trailing Japan by a slight margin. Combining exports and imports, China was Taiwan's largest trading partner, accounting for 21.7% of Taiwan's total trade during this period.

Table 2: Summary statistics

	2007					2017				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
labor supply rate (r_{icst})	10,033	0.261	0.043	0.030	0.5	9,377	0.244	0.035	0.030	0.5
mean wage income (w_{cst})	10,033	950.439	304.691	194.651	3568.602	9,377	1050.344	318.766	146.737	4217.438
mean wage rate (w_{cst})	10,033	150.401	46.615	38.140	624.505	9,377	178.613	51.664	20.654	738.052
years of schooling (z_{icst})	10,033	11.159	3.626	0	22	9,377	12.173	3.605	0	22
nomem	10,033	4.570	2.067	1	17	9,377	4.848	2.633	1	21
shr20less	10,033	0.197	0.213	0	1	9,377	0.205	0.240	0	0.833
shr65abv	10,033	0.087	0.180	0	1	9,377	0.129	0.210	0	1
shrjob	10,033	0.615	0.239	0.125	1	9,377	0.600	0.262	0.0833333	1
shrmale	10,033	0.466	0.213	0	1	9,377	0.453	0.231	0	1
gender										
female	10,033	0.369	0.482	0	1	9,377	0.351	0.477	0	1
male	10,033	0.631	0.482	0	1	9,377	0.649	0.477	0	1
age	10,033	40.902	12.542	15	91	9,377	44.570	12.909	16	88
marriage										
divorced	10,033	0.038	0.192	0	1	9,377	0.051	0.221	0	1
married	10,033	0.651	0.477	0	1	9,377	0.613	0.487	0	1
single	10,033	0.287	0.453	0	1	9,377	0.306	0.461	0	1
widowed	10,033	0.024	0.152	0	1	9,377	0.029	0.168	0	1
firmsize	10,033	3.915	2.269	1	8	9,377	4.035	2.368	1	8
worktype										
employee	10,033	0.744	0.436	0	1	9,377	0.714	0.452	0	1
employer	10,033	0.041	0.198	0	1	9,377	0.030	0.171	0	1
self-employed	10,033	0.143	0.350	0	1	9,377	0.181	0.385	0	1
unpaid family worker	10,033	0.071	0.258	0	1	9,377	0.075	0.264	0	1
workexp	10,033	121.715	126.401	1	873	9,377	140.931	123.220	1	780
$\ln \tau_{cst,TW}$ (1)	10,031	5.072	6.497	0.000132	41.085	9,366	4.530	6.719	0.000075	42.605
$\ln \tau_{cst,TW}$ (2)	10,031	5.072	6.497	0.000132	41.085	9,366	4.526	6.721	0.000075	42.605
$\ln \tau_{cst,TW}$ (3)	10,031	5.079	6.492	0.000132	41.085	9,366	4.533	6.717	0.000075	42.605
$\ln \tau_{cst,CN}$ (1)	10,031	11.139	11.459	0.000644	50.608	9,366	8.652	10.134	0.000205	45.548
$\ln \tau_{cst,CN}$ (2)	10,031	11.139	11.459	0.000644	50.608	9,366	8.648	10.137	0.000205	45.548
$\ln \tau_{cst,CN}$ (3)	10,031	11.142	11.456	0.000644	50.608	9,366	8.652	10.133	0.000205	45.548

Notes: As noted in the main text, the sample includes individuals engaged in Primary/Manufacturing sectors, and drops observations where the individuals are engaged in the Services sectors, unemployed (UNEMP) or not in the labor force (NILF). The index following $\ln \tau_{cst,TW}$ and $\ln \tau_{cst,CN}$ corresponds to the three variations on how the 4-digit level tariff rates for Agriculture sectors (for which 4-digit employment data are not available) are aggregated to the 2-digit sector level, based on: (1) weighted average by initial year (2007) import values; (2) weighted average by current year import values; and (3) simple average.

(1) weighted average by initial year (2007) import values, (2) weighted average by current year import values, and (3) simple average.

In sum, let $\ln \tau_{jt}$ indicate one plus the tariff rate (in logs) at the 4-digit level. The county-sector-year tariff exposure is measured by: $\ln \tau_{cst} \equiv \sum_{j \in s} \frac{L_{cjt}}{L_{jt}} \ln \tau_{jt}$ for $j \in s$ and for s in Mining/Manufacturing/Services 2-digit sectors, and $\ln \tau_{cst} \equiv \frac{L_{cst}}{L_{st}} \ln \tau_{st}$ for s in Agriculture 2-digit sectors. We consider a county-sector-year's tariff exposures due to: the tariffs levied by Taiwan ($\ln \tau_{cst,TW}$) against imports from China, and the tariffs levied by China ($\ln \tau_{cst,CN}$) against imports from Taiwan, respectively. They are used as instruments for $\ln w_{cst}$. Correspondingly, we use the interaction of these two tariff exposure measures and the ability level of individuals ($\ln \tau_{cst,TW} * z_{icst}$ and $\ln \tau_{cst,CH} * z_{icst}$) as instruments for $\ln w_{cst} * z_{icst}$ in

Equation (10).

In estimations, we drop the Service sectors, as observations on import tariffs for Service sectors are mostly missing. We also drop observations where the individuals are unemployed (UNEMP) or not in the labor force (NILF), because there are no convincing ways to construct these observations' tariff exposures. All remaining observations have positive labor supply rates ($r > 0$). In sum, our sample consists of individuals employed across 32 Primary/Manufacturing sectors, located across 20 counties/cities, and observed during the period 2007–2017. The summary statistics for the key variables and control variables are provided in Table 2 for the start and the end years of the study period.

For example, in 2007 (2017), the survey includes 28,841 (26,238) individuals, out of which 880 (458) are UNEMP or NILF, and 17,928 (16,403) are engaged in the Services sectors, with the remaining 10,033 (9,377) engaged in the Primary/Manufacturing sectors.

3.2 Estimation Results

We estimate Equation (10) based on the IV/2SLS estimator. Table 3 reports the results when the potential wage, $\ln w_{cst}$, faced by individual i of county-sector cs in year t is measured by the weighted average "wage income" of county-sector-year cst. Recall that $\ln w_{cst}$ is instrumented by the tariff exposures ($\ln \tau_{cst,TW}, \ln \tau_{cst,CN}$) of county-sector-year cst. Accordingly, the interaction term of wage income and skill levels, $\ln w_{cst} * z_{icst}$, is instrumented by ($\ln \tau_{cst,TW} * z_{icst}, \ln \tau_{cst,CN} * z_{icst}$). Columns (1) – (3) correspond to the three variations in constructing the average tariffs at the 2-digit level for the agriculture sectors, based on: (1) weighted average by initial year (2007) import values, (2) weighted average by current year import values, and (3) simple average of the ROCSIC 4-digit level tariff rates.

Columns (1)–(3) show that the elasticity of the labor-supply rate with respect to the potential wage income is positive and significant. Furthermore, the elasticity is found to decrease with the skill level of the individual (measured by his/her years of schooling), as indicated by the negative and statistically significant coefficient estimate for the interaction term, $\ln w_{cst} * z_{icst}$. The elasticity of the labor-supply rate with respect to the potential wage income remains positive for individuals with the longest years of schooling ($\beta_w + \beta_{wz} * 22 > 0$). These results support the theory's predictions in the case where $\epsilon > 1$: a positive elasticity of labor supply rate with respect to potential wages, with the elasticity decreasing in the skill level. The estimates are very similar across the three columns, robust to how the average tariffs at the 2-digit level for the agriculture sectors are constructed. The tariff exposure instruments are also shown to pass the Hansen test for exogeneity, and the F-test

Table 3: Labor supply rate vs. **wage income** × skill levels

ln (labor supply rate)	(1)	(2)	(3)
$\ln w_{cst}$	0.156**	0.156**	0.156**
[$\ln \tau_{cst,TW}$, $\ln \tau_{cst,CN}$]	(0.0756)	(0.0755)	(0.0756)
$\ln w_{cst} * z_{icst}$	-0.00276*	-0.00275*	-0.00274*
[$\ln \tau_{cst,TW} * z_{icst}$, $\ln \tau_{cst,CN} * z_{icst}$]	(0.00153)	(0.00153)	(0.00153)
z_{icst}	0.0190*	0.0189*	0.0188*
	(0.0106)	(0.0106)	(0.0106)
nomem	0.000706*	0.000706*	0.000706*
	(0.000360)	(0.000360)	(0.000360)
shrjob	0.0221***	0.0221***	0.0221***
	(0.00401)	(0.00401)	(0.00401)
2.gender	0.0276***	0.0276***	0.0276***
	(0.00186)	(0.00186)	(0.00186)
age	0.00793***	0.00793***	0.00794***
	(0.000530)	(0.000530)	(0.000530)
age_sq	-0.000113***	-0.000113***	-0.000113***
	(0.00000637)	(0.00000637)	(0.00000637)
firmsize	0.00864***	0.00864***	0.00864***
	(0.000729)	(0.000729)	(0.000729)
2.worktype	0.0617***	0.0618***	0.0618***
	(0.00474)	(0.00474)	(0.00474)
3.worktype	0.0149***	0.0149***	0.0149***
	(0.00450)	(0.00450)	(0.00450)
4.worktype	0.0345***	0.0345***	0.0345***
	(0.00442)	(0.00442)	(0.00442)
workexp	0.0000489***	0.0000489***	0.0000489***
	(0.0000115)	(0.0000115)	(0.0000115)
County-Year FE	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes
No. of Obs.	105798	105798	105798
Hansen J statistic	1.589	1.590	1.614
p-value of Hansen J statistic	0.452	0.452	0.446
dof of Hansen J statistic	2	2	2
F statistic for weak identification	74.31	74.33	74.36

Notes: Estimation of Equation (10) based on IV/2SLS estimator. The potential wage, $\ln w_{cst}$, faced by individual i of county-sector cs in year t is measured by the weighted average wage income of county-sector-year cst, instrumented by the tariff exposures ($\ln \tau_{cst,TW}$, $\ln \tau_{cst,CN}$) of county-sector-year cst. The interaction term of wage income and skill levels, $\ln w_{cst} * z_{icst}$, is instrumented by ($\ln \tau_{cst,TW} * z_{icst}$, $\ln \tau_{cst,CN} * z_{icst}$). Columns (1)–(3) correspond to the three variations in constructing the average tariffs at the 2-digit level for the agriculture sectors. Refer to Table 1 for the definition of the variables. The coefficient estimates of covariates that are statistically insignificant are omitted from the table to conserve space; these include shr20less, shr65abv, shrmale, and marriage. The baseline categories of gender (female) and worktype (employee) are omitted. Robust standard errors are in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

for identification.

The coefficient estimates for the other covariates are also informative. The labor-supply rate tends to be higher for higher-skill individuals, another theoretical prediction under $\epsilon > 1$ (Proposition 1). The labor-supply rate also tends to be higher for individuals in households with more members and larger shares of members with jobs, male and older individuals, and individuals working for larger firms and with longer tenures at the current firm. Individuals who are employers also tend to work longer hours than individuals who are unpaid family workers, self-employed, or employees in that order.

In Table 4, we verify the robustness of the benchmark results and measure $\ln w_{cst}$ instead by the potential wage adjusted for working hours of county-sector-year *cst*. The estimation results based on the alternative measure are fairly similar to the benchmark, qualitatively and quantitatively.

In Table 5, we further verify the robustness of the results based on IV Poisson estimator instead of the baseline IV 2SLS estimator. In this case, instead of estimating the log-linearized version of Equation (3) as in Equation (10), we estimate Equation (3) in its original scale with an additive error term. This is numerically equivalent to a Poisson Pseudo Maximum Likelihood (PPML) estimator (Silva and Tenreyro, 2006), with labor supply rate (r) as the dependent variable, and with the same set of covariates as in the log-linearized version. The PPML estimator gives less weight to observations at the lower (upper) tail than the log-linearized model (the standard NLS estimator, respectively). The IV Poisson estimator further allows us to use the tariff exposure measures as instruments for the potential wage rate. With the alternative estimator, we continue to find that the response of the labor-supply rate with respect to the potential wage rate decreases with the skill levels of the individual and remains positive and significant throughout the range of observed years of schooling. The estimates are very similar across the three columns, robust to how the average tariffs at the 2-digit level for the agriculture sectors are constructed. The tariff exposure instruments are also shown to pass the Hansen test for exogeneity.[5] The qualitative pattern of the coefficient estimates for the other covariates is also similar to Table 4, except that now the fraction of male members (shrmale) in an individual's household has a negative effect on his/her labor market supply rate, while the effect of household size (nomem) has turned insignificant.

In sum, the empirical analysis and results provided in this section support the overall theoretical predictions and mechanisms proposed in Section 2 for the case of $\epsilon > 1$ where

[5]The first stage F-test is not rendered by the *ivpoisson* module, but the strength of the instruments is indicated in Table 4.

Table 4: Labor supply rate vs. **wage rate** × skill levels

ln (labor supply rate)	(1)	(2)	(3)
ln w_{cst}	0.163*	0.162*	0.162*
[ln $\tau_{cst,TW}$, ln $\tau_{cst,CN}$]	(0.0868)	(0.0868)	(0.0868)
ln w_{cst} * z_{icst}	-0.00319*	-0.00318*	-0.00317*
[ln $\tau_{cst,TW}$ * z_{icst}, ln $\tau_{cst,CN}$ * z_{icst}]	(0.00170)	(0.00169)	(0.00169)
z_{icst}	0.0162*	0.0161*	0.0160*
	(0.00866)	(0.00865)	(0.00864)
nomem	0.000694*	0.000694*	0.000693*
	(0.000362)	(0.000362)	(0.000362)
shrjob	0.0223***	0.0223***	0.0223***
	(0.00409)	(0.00409)	(0.00409)
2.gender	0.0278***	0.0278***	0.0278***
	(0.00187)	(0.00187)	(0.00187)
age	0.00795***	0.00795***	0.00795***
	(0.000535)	(0.000535)	(0.000535)
age_sq	-0.000113***	-0.000113***	-0.000113***
	(0.00000640)	(0.00000640)	(0.00000640)
firmsize	0.00877***	0.00877***	0.00877***
	(0.000715)	(0.000715)	(0.000715)
2.worktype	0.0623***	0.0623***	0.0623***
	(0.00475)	(0.00474)	(0.00475)
3.worktype	0.0149***	0.0149***	0.0149***
	(0.00460)	(0.00460)	(0.00460)
4.worktype	0.0349***	0.0349***	0.0349***
	(0.00473)	(0.00473)	(0.00473)
workexp	0.0000495***	0.0000495***	0.0000495***
	(0.0000116)	(0.0000116)	(0.0000116)
County-Year FE	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes
No. of Obs.	105798	105798	105798
Hansen J statistic	1.929	1.928	1.957
p-value of Hansen J statistic	0.381	0.381	0.376
dof of Hansen J statistic	2	2	2
F statistic for weak identification	57.99	58.00	58.01

Notes: Estimation of Equation (10) based on IV/2SLS estimator. The potential wage, $\ln w_{cst}$, faced by individual i of county-sector cs in year t is measured by the weighted average wage rate of county-sector-year cst, instrumented by the tariff exposures ($\ln \tau_{cst,TW}$, $\ln \tau_{cst,CN}$) of county-sector-year cst. The interaction term of wage rate and skill levels, $\ln w_{cst} * z_{icst}$, is instrumented by ($\ln \tau_{cst,TW} * z_{icst}$, $\ln \tau_{cst,CN} * z_{icst}$). Columns (1)–(3) correspond to the three variations in constructing the average tariffs at the 2-digit level for the agriculture sectors. Refer to Table 1 for the definition of the variables. The coefficient estimates of covariates that are statistically insignificant are omitted from the table to conserve space; these include shr20less, shr65abv, shrmale, and marriage. The baseline categories of gender (female) and worktype (employee) are omitted. Robust standard errors are in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 5: Labor supply rate vs. **wage rate** × skill levels – by IV Poisson

labor supply rate	(1)	(2)	(3)
$\ln w_{cst}$	0.136*	0.136*	0.136*
$[\ln \tau_{cst,TW}, \ln \tau_{cst,CN}]$	(0.0716)	(0.0716)	(0.0716)
$\ln w_{cst} * z_{icst}$	-0.00255*	-0.00255*	-0.00255*
$[\ln \tau_{cst,TW} * z_{icst}, \ln \tau_{cst,CN} * z_{icst}]$	(0.00147)	(0.00147)	(0.00147)
z_{icst}	0.0127*	0.0127*	0.0126*
	(0.00751)	(0.00750)	(0.00749)
shrjob	0.0173***	0.0173***	0.0173***
	(0.00339)	(0.00339)	(0.00339)
shrmale	-0.00690**	-0.00690**	-0.00690**
	(0.00320)	(0.00320)	(0.00320)
2.gender	0.0280***	0.0280***	0.0280***
	(0.00155)	(0.00155)	(0.00155)
age	0.00688***	0.00688***	0.00688***
	(0.000413)	(0.000413)	(0.000413)
age_sq	-0.0000969***	-0.0000969***	-0.0000969***
	(0.00000490)	(0.00000490)	(0.00000490)
firmsize	0.00634***	0.00634***	0.00635***
	(0.000573)	(0.000573)	(0.000573)
2.worktype	0.0566***	0.0566***	0.0567***
	(0.00398)	(0.00398)	(0.00398)
3.worktype	0.0153***	0.0153***	0.0153***
	(0.00368)	(0.00368)	(0.00368)
4.worktype	0.0294***	0.0294***	0.0294***
	(0.00395)	(0.00395)	(0.00395)
workexp	0.0000386***	0.0000386***	0.0000386***
	(0.00000898)	(0.00000898)	(0.00000898)
County-Year FE	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes
No. of Obs.	105798	105798	105798
Hansen J statistic	3.595	3.584	3.587
p-value of Hansen J statistic	0.166	0.167	0.166
dof of Hansen J statistic	2	2	2

Notes: Estimation of Equation (10) based on IV Poisson estimator. The potential wage, $\ln w_{cst}$, faced by individual i of county-sector cs in year t is measured by the weighted average wage rate of county-sector-year cst, instrumented by the tariff exposures $(\ln \tau_{cst,TW}, \ln \tau_{cst,CN})$ of county-sector-year cst. The interaction term of wage rate and skill levels, $\ln w_{cst} * z_{icst}$, is instrumented by $(\ln \tau_{cst,TW} * z_{icst}, \ln \tau_{cst,CN} * z_{icst})$. Columns (1)–(3) correspond to the three variations in constructing the average tariffs at the 2-digit level for the agriculture sectors. Refer to Table 1 for the definition of the variables. The coefficient estimates of covariates that are statistically insignificant are omitted from the table to conserve space; these include: nomem, shr20less, shr65abv, and marriage. The baseline category of gender (female) and that of worktype (employee) are omitted. Robust standard errors are in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

the market goods and the home good are substitutes.

4 An Open-Economy Model and Welfare Gains from Trade

In this section, we embed the mechanism of individual labor supply choice into a standard general equilibrium trade model to study how the endogeneity of labor supply due to this mechanism affects the welfare gains from trade. We choose the canonical Ricardian model of Eaton and Kortum (2002) for two reasons. First, it is flexible for quantitative analyses. Second, it belongs to the ACR class, which is our main benchmark for comparison. It will be shown shortly that our model (the Eaton-Kortum model with our endogenous labor-supply mechanism) does not belong to the ACR class, but the welfare formula can be decomposed into an ACR statistic and a labor-supply factor. Hence, comparing the original Eaton-Kortum model and our model sheds light on how endogenous labor supply affects welfare gains from trade.

4.1 The Eaton-Kortum Model with Endogenous Labor Supply

Suppose there are K countries in the world, each with a given number of workers L_k where $k \in \{1, 2, \ldots, K\}$. The workers consume a continuum of market goods $\omega \in [0, 1]$ and a home good, and are required to allocate their time between working and home production as modeled in Section 2. We assume that the preferences, time endowment $\bar{n}$, productivity of home production, and the distribution of worker skill $H(z)$ are all identical across countries.

Each market good ω is produced by combining labor and intermediate input. The output is then either consumed by workers as final goods or aggregated into intermediate input bundles $m(\omega)$ by the same CES aggregator as for consumption (the structure known as a roundabout production structure):

$$m(\omega) = \left(\int_{\omega' \in \Omega} q(\omega')^{\frac{\sigma-1}{\sigma}} \, d\omega' \right)^{\frac{\sigma}{\sigma-1}} .$$

The production function for each good ω is given by:

$$q_i(\omega) = B\varphi_i(\omega) \left[l_i(\omega) \right]^{\alpha} \left[m_i(\omega) \right]^{1-\alpha},$$

where $B \equiv \left[\alpha^{\alpha} (1-\alpha)^{1-\alpha} \right]^{-1}$ with $\alpha \in (0, 1)$. The Hicks-neutral productivity $\varphi_i(\omega)$ is drawn *i.i.d.* from a Fréchet distribution, whose cumulative density is given by $F_i(\varphi) = e^{-T_i \varphi^{-\kappa_\varphi}}$, where $T_i > 0$ is a country-specific scale parameter, and $\kappa_\varphi > 1$ denotes the tail index of the productivity distribution. The goods markets are perfectly competitive.

Perfect competition and constant-returns-to-scale production technology imply that the price of each good ω in country k is given by the (delivered) marginal cost of the least costly source for this good:

$$p_k(\omega) = \min_i \left\{ \frac{\tau_{ki} w_i^{\alpha} P_i^{1-\alpha}}{\varphi_i(\omega)} \right\},$$

where τ_{ki} denotes the iceberg trade cost to ship goods from country i to country k, and w_i and P_i denote the wage and the aggregate price index of the source country i, respectively. Standard derivation yields the price index as:

$$P_k = \left[\sum_{i=1}^{K} T_i \tau_{ki}^{-\kappa_\varphi} w_i^{-\alpha\kappa_\varphi} P_i^{-(1-\alpha)\kappa_\varphi} \right]^{-\frac{1}{\kappa_\varphi}} \left(\Gamma \left(\frac{1-\sigma+\kappa_\varphi}{\kappa_\varphi} \right) \right)^{\frac{1}{1-\sigma}}, \tag{11}$$

where Γ is the Gamma function.

Let X_k denote country k's total expenditure and X_{ki} denote country k's import from country i. Country k's expenditure share on goods from country i is given by:

$$\pi_{ki} \equiv \frac{X_{ki}}{X_k} = \frac{T_i \tau_{ki}^{-\kappa_\varphi} w_i^{-\alpha\kappa_\varphi} P_i^{-(1-\alpha)\kappa_\varphi}}{\sum_j T_j \tau_{kj}^{-\kappa_\varphi} w_j^{-\alpha\kappa_\varphi} P_j^{-(1-\alpha)\kappa_\varphi}}.$$

Given that country i's effective labor supply is:

$$\begin{aligned} N_i \equiv & L_i \bar{n} \int_1^\infty r(z)\, z dH(z) \\ = & L_i \bar{n} \int_1^\infty \kappa_z \frac{\left(\frac{\theta}{1-\theta}\right)^{\epsilon} \left(\frac{w_i}{P_i}\right)^{\epsilon-1} z^{\epsilon-1}}{1 + \left(\frac{\theta}{1-\theta}\right)^{\epsilon} \left(\frac{w_i}{P_i}\right)^{\epsilon-1} z^{\epsilon-1}} z^{-\kappa_z} dz, \end{aligned}$$

the labor market clearing condition in country i is:

$$Y_i = w_i N_i = \alpha \sum_{k=1}^{K} \pi_{ki} X_k.$$

Balanced trade implies that the expenditure is also the total revenue ($X_i = \sum_{j=1}^{K} \pi_{ki} X_k$), and

$1-\alpha$ share of it is spent on intermediate goods. Thus, the goods market clearing condition can be written as:

$$X_i = Y_i + (1-\alpha) X_i = Y_i + (1-\alpha) \sum_{k=1}^{K} \pi_{ki} X_k,$$

where the first equality is the split of the total revenue.

4.2 *Welfare Formula*

In the trade models that belong to the ACR class, the welfare is characterized by the real income $W^{ACR} = wL/P$, in which L does not matter as labor is inelastically supplied. The effect of an infinitesimal change in trade cost τ on welfare is given by the "local formula" $d \ln W^{ACR} = \frac{1}{\xi} d \ln \lambda$, where λ denotes the expenditure share on domestic goods and $\xi \equiv \partial \ln (X_X/X_D) / \partial \ln \tau$ denotes the trade elasticity, which is a constant in the ACR class. The consequence of a large change in τ on welfare, which we refer to as the "global formula", is given by $\widehat{W} = \hat{\lambda}^{\frac{1}{\xi}}$ where $\hat{x} \equiv x^{new}/x^{old}$. As mentioned, the Eaton-Kortum model with inelastic labor supply belongs to the ACR class, and the welfare gains from trade compared with autarky are:

$$\widehat{W}_k^{EK} \equiv \frac{W_k^{EK}}{W_{k,autarky}^{EK}} = \pi_{kk}^{-\frac{1}{\alpha\kappa\varphi}}. \tag{12}$$

As in Eaton and Kortum (2002), the real wages in our model are proportional to the domestic expenditure share:

$$\frac{w_k}{P_k} \propto T_k^{\frac{1}{\alpha\kappa\varphi}} \pi_{kk}^{-\frac{1}{\alpha\kappa\varphi}}.$$

This implies that the changes in real wages are still captured by the ACR formula. As shown in Section 2, the worker labor-supply rate depends on real wages and hence the domestic expenditure share. Let the superscript *LS* (Labor Supply) denote our model. We can derive the welfare formula as follows.

Proposition 4. *The local formula of welfare gains from trade is given by:*

$$d \ln W_k^{LS} = d \ln \left(\frac{w_k}{P_k} \right) \times R_v \left(\frac{w_k}{P_k} \right),$$

where

$$R_v\left(\frac{w_k}{P_k}\right) \equiv E_z\left[r\left(z;\frac{w_k}{P_k}\right)\frac{V\left(z;\frac{w_k}{P_k}\right)}{E_z\left[V\left(z;\frac{w_k}{P_k}\right)\right]}\right] = \int_z r\left(z;\frac{w_k}{P_k}\right)\frac{V\left(z;\frac{w_k}{P_k}\right)}{E_z\left[V\left(z;\frac{w_k}{P_k}\right)\right]}dH(z)$$

is the aggregate labor-supply rate given by the utility-weighted average of individual labor-supply rates. By definition, $R_v(w_k/P_k) \in (0,1)$. *The local formula can be further written as:*

$$d\ln W_k^{LS} = \underbrace{-\frac{1}{\alpha\kappa_\varphi}d\ln\pi_{kk}}_{\text{ACR statistic}}\times R_v\left(\frac{w_k}{P_k}\right). \tag{13}$$

The global formula of welfare gains from trade compared with autarky is given by:

$$\begin{aligned}\widehat{W}_k^{LS} \equiv \frac{W_k^{LS}}{W_{k,autarky}^{LS}} &= \pi_{kk}^{-\frac{1}{\alpha\kappa_\varphi}} \times \exp\left\{\int_{\pi_{kk}}^{1}\left[1-R_v\left(\frac{w_k}{P_k}\right)\right]\frac{-1}{\alpha\kappa_\varphi}d\ln\pi\right\} \\ &\equiv ACR_k^{LS}\times LSF_k,\end{aligned} \tag{14}$$

where the labor-supply factor LSF_k *lies in the range of* $(0,1)$.

Proof. See Appendix A.3. □

In words, Equation (13) shows that local changes in welfare in the current framework are captured by changes in real wages, modified by the aggregate labor-supply rate multiplicatively. The changes in real wages coincide with the ACR statistic. The aggregate labor-supply rate reflects the fraction of time allocated to working in the labor market, and being less than one, dampens potential welfare gains from trade in the market goods. Equation (14) suggests that the reduction in welfare gains from trade due to this labor-supply mechanism decreases in the labor-supply rate (at the intensive margin) and increases when π_{kk} is smaller (at the extensive margin). Naturally, the larger the labor-supply rate, the closer is the equilibrium to that under the full labor-supply models; and the larger the ACR gains (the smaller π_{kk} is), the more is at stake. Other things being equal, a country with a higher degree of trade openness (smaller π_{kk}) tends to have a higher real wage, which, in turn, implies a higher (lower) aggregate labor-supply rate when $\epsilon > 1$ ($\epsilon < 1$) but also higher ACR gains. The net effect on *LSF* depends on which margin dominates. The dampening effect is stronger (the *LSF* is smaller) if the latter dominates the former.

Our model generates inelastic labor supply in two special cases: $\epsilon = 1$ or $\theta = 1$. We elaborate on the implications in the following corollary.

Corollary 5. *The labor supply is inelastic if and only if either $\epsilon = 1$ or $\theta = 1$. In either case, the aggregate labor-supply rate becomes a constant, i.e., $R_v(w_k/P_k) = \theta$. The welfare gains from trade are given by the ACR formula but with the difference that when compared with the ACR class with full labor supply, the trade elasticity is changed from $-\alpha\kappa_\varphi$ to $-\alpha\kappa_\varphi/\theta$.*

Proof. When $\epsilon = 1$, the preferences become Cobb-Douglas:

$$U = C^\theta c_h^{1-\theta}.$$

It is readily verified that $r_i = \theta$ holds for all workers. Thus, $R_v(w_k/P_k) = \theta$, and the resulting formula for welfare gains from trade is given by the ACR statistic with a constant trade elasticity $-\alpha\kappa_\varphi/\theta$. That is,

$$d\ln W_k^{LS} = -\frac{\theta}{\alpha\kappa_\varphi} d\ln \pi_{kk}.$$

This implies a global formula given by $\hat{\pi}_{kk}^{-\frac{\theta}{\alpha\kappa_\varphi}}$.

When $\theta = 1$, the utility function consists of only market consumption. Hence, the labor-supply rate equals 1 for all workers; the model is reduced to the Eaton-Kortum model. Therefore, both the local and global ACR formulas hold. □

Corollary 5 shows that when the preferences become Cobb-Douglas, the welfare gains from trade in the current model are a θ fraction of those given by the ACR statistic for infinitesimal changes in trade costs. For large changes in trade costs, the welfare gains from trade depend on the changes in the domestic expenditure shares, but the responsiveness is dampened. The case of $\theta = 1$ simply reduces the current model to the Eaton-Kortum model.

We next evaluate the quantitative importance of these welfare components. That is, we will gauge the quantitative magnitudes of both ACR_k^{LS} and ACR_k^{EK}, as well as that of the labor-supply factor. Note that the welfare gains from trade in the current model are not necessarily smaller compared with models with inelastic labor supply, even though the labor-supply factor is less than one. This is because ACR_k^{LS} and $\widehat{W}_k^{EK} = ACR_k^{EK}$ may still differ in general. To gauge the quantitative magnitude of the labor-supply factor and the difference in welfare gains from trade across models, we conduct quantitative analysis in the next section.

5 A Quantitative Analysis of Welfare Gains from Trade

We conduct a quantitative analysis to assess the role of labor supply in welfare gains from trade. In particular, we use the same set of calibrated model parameters to compute welfare gains from trade in our LS model and in the EK model. We examine how gains from trade differ between the two models and how the labor-supply factor contributes to the differences.

5.1 Calibration

In order to calculate welfare gains from trade, the current model needs to be fully calibrated due to the labor-supply factor. The labor-supply factor is a function of workers' labor supply rates, which depend on the level of real wage and in turn require a complete characterization of the equilibrium. As such, hat algebra is not sufficient for this purpose.

Two sets of parameters need to be calibrated: labor-supply side and labor-demand side. We discuss the labor-demand side first, as the labor-supply side requires the use of labor-demand-side parameters. We compile bilateral trade flows and trade cost proxies based on World Input-Output Data (WIOD) and Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). The sample covers 42 countries, which are the countries covered in WIOD, for the period 2007–2014.[6] To calibrate the labor-supply-side parameters, we use the Manpower Utilization Survey at the worker level as in our empirical analysis.

As in Eaton and Kortum (2002), the trade elasticity is given by the tail index of productivity distribution κ_φ. Following Simonovska and Waugh (2014), we set $\kappa_\varphi = 4$. To be consistent with Zipf's law in firm size, we set the elasticity of substitution σ to be such that the tail index of firm size $\kappa_\varphi/(\sigma - 1)$ equals 1.06 as documented in Luttmer (2007). This entails $\sigma = 4.77$. For the parameter $1 - \alpha$, which indicates the share of intermediate inputs in production, we use the US economy's share of intermediate input to gross output pooled across sectors, based on the Social Economic Account (SEA) of WIOD for the year 2014. This implies that $\alpha = 0.56$.

Given the combined data set of WIOD and CEPII for the period 2007–2014, we estimate the following gravity equation by the Pseudo Poisson Maximum Likelihood (PPML)

[6] The latest WIOD Release 2016 covers periods only up to 2014. Cyprus is excluded from the analysis because zero trade is prevalent between the country and its trading partners.

estimator:

$$X_{knt} = \exp\left(\ln \tau_{knt}^{-\kappa_\varphi} + D_{kt} + D_{nt}\right) + \varepsilon_{knt},$$

where X_{knt} denotes country n's export value to country k in year t (including intranational trade observations), D_{kt} and D_{nt} are importer-year and exporter-year fixed effects, ε_{knt} is the error term, and

$$\begin{aligned}\ln \tau_{knt}^{-\kappa_\varphi} =& \beta_{dist} \ln Dist_{kn} + \beta_{contig} contig_{kn} + \beta_{lang} commlang_{kn} + \beta_{col} colony_{kn} + \beta_{intra} Intra_{kn} \\ &+ \beta_{wto} WTO_{knt} + \beta_{rta} RTA_{knt}. \end{aligned} \tag{15}$$

Here, $Dist_{kn}$ is the distance between countries k and n defined by distance between capital cities.[7] The variables $contig_{kn}$ and $commlang_{kn}$ are dummy variables indicating whether countries k and n share a common border and share common languages spoken by at least 9% of the populations, respectively. The variable $colony_{kn}$ is a dummy variable indicating whether the two countries have ever shared a colonial link in or after 1945. The dummy variables WTO_{knt} and RTA_{knt} take the value 1 if the country pair are both WTO members in year t, and have a regional trade agreement in year t, respectively. The variable $Intra_{kn}$ is a dummy variable indicating whether the observation corresponds to intranational trade (i.e., if $k = n$). For intranational trade observations, all of the cross-border dummy variables are set to zeros. That is, $\ln \tau_{nn}^{-\kappa_\varphi} = \beta_{dist} \ln Dist_{nn} + \beta_{intra} Intra_{nn}$. With the given value of κ_φ and the estimated coefficients, trade cost τ_{knt} can be recovered by (15). Below we will conduct simulations for year 2014 and hence the trade cost estimates of 2014 will be used.

Next, we turn to the labor-supply side. Define:

$$\Psi_k \equiv \Theta P_k^{1-\epsilon}, \tag{16}$$

where $\Theta \equiv \left(\frac{\theta}{1-\theta}\right)^{\epsilon}$. We can rewrite the worker labor-supply rate in Equation (3) as:

$$\ln \frac{r_k(z)}{1 - r_k(z)} = \ln \Psi_k + (\epsilon - 1) \ln (w_k z). \tag{17}$$

Thus, Ψ_k and ϵ can be estimated given the worker-level labor-supply rate $r_k(z)$ and the nominal wage $w_k z$ *predicted* by workers' skill levels. We recover these parameters with a two-stage estimation procedure based on the data from Manpower Utilization Survey. In

[7]The intranational distance is defined as $0.66\sqrt{area_n/\pi}$ of country n, available from CEPII.

the first stage, we estimate a general wage equation:

$$\ln wage_{icst} = \beta_0 + \beta_z z_{icst} + \beta_{\tau,TW} \ln \tau_{cst,TW} + \beta_{\tau,CH} \ln \tau_{cst,CH} + \mathbf{X}_{icst}\boldsymbol{\beta}_x + \lambda_{ct} + \delta_{st} + \varepsilon_{icst},$$

where $wage_{icst}$ is the nominal wage rate of individual i in county c of sector s in year t, z_{icst} is the skill level of individual i in year t; $\tau_{cst,TW}$ and $\tau_{cst,CH}$ are a county-sector-year's tariff exposures due to: the tariffs levied by Taiwan against imports from China, and the tariffs levied by China against imports from Taiwan, respectively; $\mathbf{X}_{icst}$ is a list of household, individual, and workplace characteristics as documented in Section 3; and λ_{ct} and δ_{st} are county-year and sector-year FEs as defined in Section 3. Given the estimation result, we recover the component of the wage rate that is predicted by the worker's skill level:

$$\ln \widetilde{w_{icst} z_{icst}} = \tilde{\beta}_z z_{icst}.$$

In the second stage, we then estimate a generalized version of Equation (17) using the observed labor-supply rate and the skill-predicted wage rate from the first stage:

$$\ln \frac{r_{icst}}{1 - r_{icst}} = \ln \Psi_{TW} + (\epsilon - 1) \ln \widetilde{w_{icst} z_{icst}} + \lambda_{ct} + \delta_{st} + \varepsilon_{icst}.$$

As explained in Section 3, in constructing the average tariffs at the 2-digit level for the agriculture sectors, there are three possible variants: (1) weighted average by initial year (2007) import values, (2) weighted average by current year import values, or (3) simple average of the ROCSIC 4-digit level tariff rates. Based on variant 1, we obtain estimates of $\widetilde{\Psi}_{TW} = 0.293$ and $\tilde{\epsilon} = 1.180$. When the estimations are based on the other two measures, the estimates are rather similar. The fact that $\tilde{\epsilon} > 1$ is consistent with the empirical findings in Section 3.[8]

We then calibrate the Taiwanese price index P_{TW}, so as to recover the parameter θ from $\widetilde{\Psi}_{TW}$ given Equation (16). We solve for P_{TW} using Equation (11) recursively given the information on $\{T_k, \tilde{\tau}_{kn}, w_k\}$, where $\tilde{\tau}_{kn}$ are estimated above based on Equation (15) for year 2014. We calibrate the Fréchet scaling parameter T_k using the country-level TFP measure from Penn World Table 10,[9] where the level for the US is normalized to 1. The wage rate in each country w_k is calibrated by the labor compensation per worker, computed using the

[8] Our estimate of $\tilde{\epsilon}$ is lower than the previous estimates, which are roughly around 2, in the business-cycle and life-cycle literature. Rogerson and Wallenius (2016), however, argue that this commonly used benchmark value is not a robust empirical regularity, as it is difficult to reconcile with time-use evidence.

[9] The average across years for the period 2007–2014 is used.

ratio of total labor compensation (LAB) in US dollars and the number of people engaged in production (EMP) for year 2014 from SEA of WIOD. The labor force in each country L_k is measured by EMP, where we also normalize the levels by setting $L_{US} = 1$. Following this procedure, we obtain $\tilde{\theta} \approx 0.522$ based on Equation (16) given $\widetilde{\Psi}_{TW}$, $\tilde{\epsilon}$, and $\tilde{P}_{TW}$.

For the tail index of worker ability κ_z, Appendix A.4 shows that when $\epsilon > 1$, the income level y has a Pareto distribution such that its probability density function is:

$$f_y(y) = \frac{\kappa_z \left[r(y)\,\overline{n}w\right]^{\kappa_z}}{\epsilon\left[1 - r(y)\right] + r(y)} y^{-\kappa_z - 1}, \; y \in \left[w\overline{n}\frac{\Psi w^{\epsilon-1}}{1 + \Psi w^{\epsilon-1}}, \infty\right).$$

Therefore, the tail index of income distribution is also given by κ_z. Following Gabaix et al. (2016), we set $\kappa_z = 1.515$.

5.2 *Labor Supply and Gains from Trade*

We investigate the role of elastic labor supply by comparing the welfare gains from trade between the LS and the EK models. We first simulate the equilibrium allocations in our LS model with the calibrated parameters. By treating the labor supply obtained from the LS model as the size of the labor force, we simulate the equilibrium allocations in the EK model with the same set of parameters. For each model, we inspect the changes in welfare due to reductions in trade costs, and for LS we further decompose the welfare changes into the ACR component and the labor-supply factor. We consider two cases: (1) moving from autarky to the status quo with the calibrated trade costs, and (2) a 25% reduction in international trade costs from the status quo (the intranational trade costs are kept unchanged). The results are summarized in Table 6. Note that the calibrated aggregate labor-supply rates R_v under the status quo are in the range of 0.61–0.69 across countries, with a population-weighted average of 0.62.

The table indicates that the ACR components are exactly the same in the LS and EK models ($ACR^{LS} = \widehat{W}^{EK} \equiv ACR^{EK}$) for the case of moving from autarky to status quo. To understand this, first note that the labor-demand side is the same between the two models, whereas the effective labor supply under the status quo is also the same by construction. Thus, the real wages are the same in these two models under the status quo. When the state of the economies moves away from the status-quo trade costs, the effective labor supply in the LS model changes while that in the EK model remains the same. In general, when the relative labor supplies change, the relative wages and real wages across countries also change. However, under autarky, the relative labor supplies do not affect the real wages, as

Table 6: Welfare Gains from Trade and Decomposition

Country	R_v at the Status Quo	From Autarky to Status Quo $\widehat{W}^{EK}$	$\widehat{W}^{LS}$	ACR^{LS}	LSF^{LS}	$\frac{ACR^{LS}}{\widehat{W}^{EK}}-1(\%)$	$\frac{\widehat{W}^{LS}-1}{\widehat{W}^{EK}-1}(\%)$	25% Reduction in Trade Costs $\widehat{W}^{EK}$	$\widehat{W}^{LS}$	ACR^{LS}	LSF^{LS}	$\frac{ACR^{LS}}{\widehat{W}^{EK}}-1(\%)$	$\frac{\widehat{W}^{LS}-1}{\widehat{W}^{EK}-1}(\%)$
Estonia	0.66	1.32	1.20	1.32	0.91	0.00	62.78	1.32	1.21	1.32	0.91	-0.15	63.47
Latvia	0.66	1.30	1.18	1.30	0.91	0.00	62.37	1.31	1.19	1.31	0.91	-0.15	62.87
Lithuania	0.66	1.24	1.15	1.24	0.93	0.00	63.11	1.27	1.17	1.26	0.93	-0.16	63.77
Luxembourg	0.68	1.22	1.15	1.22	0.94	0.00	65.77	1.24	1.16	1.24	0.93	-0.08	66.39
Cyprus	0.67	1.22	1.14	1.22	0.94	0.00	64.65	1.25	1.16	1.25	0.93	-0.08	65.32
Slovenia	0.67	1.22	1.14	1.22	0.94	0.00	64.19	1.24	1.15	1.24	0.93	-0.08	64.44
Slovakia	0.66	1.20	1.13	1.20	0.94	0.00	63.64	1.21	1.14	1.21	0.94	0.00	64.32
Finland	0.66	1.20	1.12	1.20	0.94	0.00	62.94	1.23	1.15	1.23	0.93	-0.08	63.04
Croatia	0.66	1.19	1.12	1.19	0.94	0.00	63.40	1.22	1.14	1.22	0.94	-0.08	63.68
Norway	0.66	1.19	1.12	1.19	0.94	0.00	63.40	1.23	1.15	1.23	0.93	-0.08	63.76
Austria	0.66	1.17	1.11	1.17	0.95	0.00	63.86	1.18	1.12	1.18	0.95	0.00	64.67
Malta	0.69	1.15	1.10	1.15	0.96	0.00	66.67	1.19	1.13	1.19	0.95	0.00	67.55
Ireland	0.67	1.15	1.10	1.15	0.95	0.00	64.47	1.19	1.12	1.19	0.95	0.00	65.05
Sweden	0.65	1.15	1.10	1.15	0.95	0.00	62.99	1.19	1.12	1.19	0.94	-0.08	63.10
Hungary	0.66	1.15	1.10	1.15	0.95	0.00	63.33	1.18	1.11	1.18	0.95	0.00	64.00
Czechia	0.65	1.15	1.09	1.15	0.95	0.00	63.51	1.17	1.11	1.17	0.95	-0.09	63.58
Bulgaria	0.66	1.14	1.09	1.14	0.96	0.00	64.29	1.17	1.11	1.17	0.95	-0.09	63.95
Denmark	0.67	1.13	1.09	1.13	0.96	0.00	64.93	1.16	1.11	1.16	0.95	-0.09	65.03
Belgium	0.67	1.13	1.09	1.13	0.96	0.00	65.15	1.15	1.10	1.15	0.95	0.00	65.79
Canada	0.63	1.13	1.08	1.13	0.96	0.00	61.65	1.17	1.11	1.17	0.95	0.00	61.76
Switzerland	0.67	1.12	1.08	1.12	0.96	0.00	64.52	1.15	1.10	1.15	0.96	0.00	65.31
Greece	0.65	1.12	1.08	1.12	0.96	0.00	63.56	1.15	1.10	1.15	0.95	-0.09	63.58
Poland	0.65	1.10	1.06	1.10	0.97	0.00	63.54	1.12	1.08	1.12	0.96	0.00	64.17
Portugal	0.66	1.09	1.06	1.09	0.97	0.00	64.13	1.12	1.08	1.12	0.96	0.00	64.75
Romania	0.65	1.09	1.06	1.09	0.97	0.00	63.64	1.12	1.07	1.12	0.96	0.00	63.79
Netherlands	0.67	1.08	1.06	1.08	0.97	0.00	66.27	1.10	1.07	1.10	0.97	0.00	65.38
France	0.65	1.08	1.05	1.08	0.97	0.00	63.86	1.10	1.07	1.10	0.97	0.00	64.08
Russia	0.62	1.08	1.05	1.08	0.97	0.00	61.04	1.10	1.06	1.10	0.96	0.00	61.17
Spain	0.65	1.07	1.05	1.07	0.98	0.00	64.29	1.09	1.06	1.09	0.97	0.00	63.83
Germany	0.65	1.07	1.04	1.07	0.98	0.00	65.15	1.08	1.05	1.08	0.97	0.00	64.63
Australia	0.63	1.07	1.04	1.07	0.98	0.00	62.32	1.10	1.06	1.10	0.97	0.00	61.54
United Kingdom	0.65	1.07	1.04	1.07	0.98	0.00	64.62	1.09	1.06	1.09	0.97	0.00	64.71
Italy	0.65	1.07	1.04	1.07	0.98	0.00	64.62	1.09	1.06	1.09	0.97	0.00	64.71
Turkey	0.65	1.06	1.04	1.06	0.98	0.00	64.06	1.09	1.06	1.09	0.97	0.00	63.95
South Korea	0.65	1.05	1.03	1.05	0.98	0.00	63.27	1.07	1.05	1.07	0.98	0.00	64.29
Mexico	0.63	1.05	1.03	1.05	0.98	0.00	63.83	1.07	1.04	1.07	0.98	0.00	63.24
USA	0.63	1.04	1.02	1.04	0.99	0.00	62.86	1.05	1.03	1.05	0.98	0.00	62.50
Taiwan	0.66	1.03	1.02	1.03	0.99	0.00	64.52	1.05	1.03	1.05	0.99	0.00	65.22
Japan	0.64	1.03	1.02	1.03	0.99	0.00	64.29	1.04	1.03	1.04	0.99	0.00	64.29
Brazil	0.62	1.03	1.02	1.03	0.99	0.00	64.00	1.04	1.02	1.04	0.99	0.00	61.54
Indonesia	0.63	1.03	1.02	1.03	0.99	0.00	60.00	1.04	1.02	1.04	0.99	0.00	62.16
India	0.62	1.02	1.01	1.02	0.99	0.00	63.16	1.03	1.02	1.03	0.99	0.00	60.71
China	0.61	1.02	1.01	1.02	0.99	0.00	58.82	1.03	1.02	1.03	0.99	0.00	64.00
Simple Average	0.65	1.12	1.08	1.12	0.96	0.00	63.66	1.14	1.09	1.14	0.96	-0.03	63.93
Weighted Average	0.62	1.03	1.02	1.03	0.99	0.00	61.50	1.04	1.03	1.04	0.98	0.00	62.84

Equation (11) can be rewritten as:

$$\left(\frac{w_k}{P_k}\right)^{-\alpha} = T_k^{-\frac{1}{\kappa_\varphi}} \tau_{kk} \left(\Gamma\left(\frac{1-\sigma+\kappa_\varphi}{\kappa_\varphi}\right)\right)^{\frac{1}{1-\sigma}}.$$

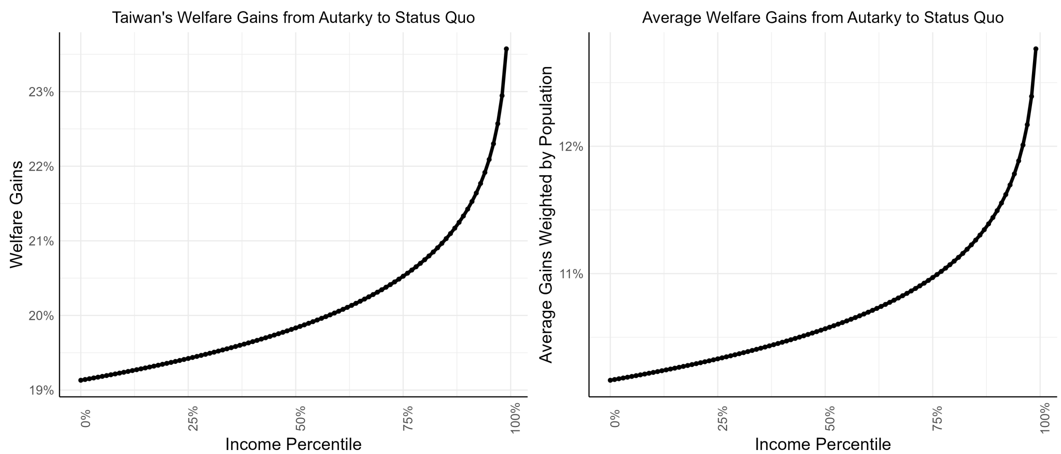
That is, the real wages are the same in these two models under autarky as well, and are solely determined by technology. As the real wages are the same under autarky and under the status quo in these two models, the implied ACR statistics are hence the same. In the second counterfactual analysis, in which the trade costs are reduced by 25%, even though the ACR components are not the same across the two models (see Table 6), their quantitative differences are negligible. This indicates that relative labor supplies do not change substantially when there are 25% reductions in all international trade costs (while the intranational trade costs are kept unchanged).

Table 6 shows that the implied welfare changes in these two models differ because the labor-supply factor dampens the welfare gains relative to the ACR statistic in the LS model. For example, in the case of Switzerland, a 12 percentage point gain in real wages ($ACR^{LS} = 1.12$) from autarky to trade is offset by the LSF by 4 percentage points ($LSF = 0.96$). As another example, Estonia sees a 32 p.p. gain in real wages but a 9 p.p. offset by the LSF. Overall, across countries, in terms of simple and population-weighted averages, the welfare gains from trade in the LS model are 64% and 62% of those in the EK model, respectively. For the case of 25% reductions in trade costs from the status quo, the simple and population-weighted averages of the welfare gains from trade in the LS model are 64% and 63% of those in the EK model, respectively. These indicate that the labor-supply mechanism strongly dampens the welfare gains from trade.

It is readily verified that the aggregate labor-supply rate positively correlates with the ACR statistic across countries in Table 6. Hence, a country that receives larger gains from trade in the market-good component tends to see smaller dampening effects at the intensive margin due to an increase in the aggregate labor-supply rate R_v; see Equation (14). However, a country with greater openness (smaller π_{kk}) also has more at stake (weighing down the LSF at the extensive margin). Table 6 suggests that for the counterfactual scenarios considered here, smaller countries with greater trade openness tend to experience larger ACR gains but also larger dampening effects.

Next, we examine how welfare gains from trade differ across individuals. The left panel of Figure 3 plots the welfare gains from trade for each income percentile in Taiwan, whereas the right panel depicts the population-weighted average of welfare gains from trade for each income percentile in our sample countries. The two panels show a similar pattern. Individuals in the higher income/skill percentiles enjoy disproportionately larger gains from trade than those in the lower percentiles. Under the Pareto distribution, the individuals at the top percentiles are much more skilled than those at the lower percentiles, and they are also much more skilled than their counterparts under, say, the log-normal distribution. By Equation (3), the labor-supply rate $r(z)$ is a concave function in z and bounded above by 1. When skill z becomes large, the effect due to increasing labor supply eventually diminishes;

Figure 3: Welfare Gains from Trade by Income Percentiles



thus, the differences in welfare gains from trade across individuals are mainly driven by the fat-tailed nature of the skill/wage distribution.

5.3 *Comparative Statics*

In this subsection, we examine the effects of key parameters on the labor supply and welfare gains from trade. In particular, we are interested in the effect of θ (the utility weight of market consumption), ϵ (the elasticity of substitution between market consumption and the home good), and κ_z (the tail index for skill and income distribution). We repeat the quantitative exercises of the previous subsection but based on alternative parametrization for the parameters of interest, and inspect how the findings differ from the benchmark. The results are reported in Table 7.

We start with an alternative value for θ that is 25% higher than the calibrated level (0.522), which corresponds to $\theta \approx 0.653$. A higher θ indicates an increased importance of market consumption, which prompts workers to supply more of their labor. When $\theta = 1$, the model is reduced to the EK model, where workers care about market consumption only. In both cases of trade liberalization, we see that a higher θ generates welfare effects that are closer to the EK model.

Second, we experiment with a higher $\epsilon \approx 5.90$, which is 5 times the benchmark calibrated level. A larger ϵ indicates that market consumption and the home good are more substitutable. By inspecting Equation (3) for the case of $\epsilon > 1$, we note that the labor-supply rate becomes more responsive to changes in real wages and skill levels when ϵ is larger. Thus, the gain from trade becomes larger and closer to its counterpart in the EK

Table 7: Comparative Statics of Welfare Gains from Trade

	Autarky to Status Quo		25% Reduction in Trade Costs	
Experiment	$\widehat{W}^{LS}$ -1	$\frac{\widehat{W}^{LS}-1}{\widehat{W}^{EK}-1}$(%)	$\widehat{W}^{LS}$ -1	$\frac{\widehat{W}^{LS}-1}{\widehat{W}^{EK}-1}$(%)
Baseline	0.077 (0.020)	63.7 (61.5)	0.092 (0.028)	63.9 (62.8)
θ being 25% larger	0.096 (0.026)	79.2 (77.8)	0.114 (0.035)	79.2 (77.7)
ϵ being 5 times larger	0.118 (0.031)	97.0 (92.8)	0.140 (0.043)	97.1 (92.5)
κ_z being set to 4	0.072 (0.019)	60.0 (58.8)	0.087 (0.027)	60.2 (59.1)

Notes: This table shows the welfare gains from trade under alternative parametrizations. The numbers shown are simple averages across countries, while those in parentheses are population-weighted averages.

model.

Third, we experiment with an increase in the tail index for the skill distribution κ_z, from 1.515 to 4, which implies a thinner tail and a smaller skill dispersion. As the effective wage rate $z \times (w/P)$ is the sufficient statistic that determines individual labor supply rate, the effect of trade (going through the real wages w/P) increases in individual skill level. In a scenario with a fatter-tailed distribution, the tail has stronger implications on the aggregate variables than the other parts of the distribution. When the tail becomes thinner, the effect of trade is muted. Thus, we observe smaller gains from trade and larger gaps from the EK model.

6 Conclusion

How much do people choose to work, and how does trade shape that decision? This paper has offered a systematic answer across three dimensions. We develop a tractable framework in which workers of heterogeneous skill allocate time between market employment and home production, and establish that real wages are a sufficient statistic for individual labor-supply decisions: production-side shocks, including trade liberalization, affect hours worked only through their effect on the real wage. When market goods and home production are substitutes — the empirically supported case — trade-induced wage gains raise hours worked, with the response diminishing in worker skill. Using Taiwanese microdata and the tariff concessions from the 2010 ECFA as instruments, we find strong empirical support for these predictions: higher wages raise labor supply across all skill groups, with decreasing elasticity for more educated workers.

The quantitative implications are substantial. Embedding the labor-supply module in the Eaton-Kortum model, we show that welfare gains from trade decompose into the standard ACR statistic and a labor-supply factor reflecting the utility-weighted share of time workers devote to market employment. Because workers allocate a substantial share of their time to home production, this factor is meaningfully below one, dampening the gains from trade relative to the standard model. Quantitatively, welfare gains in our model amount to approximately 62% of those in the Eaton-Kortum model with inelastic labor supply — a reduction of roughly 38%. The distributional pattern is also notable: higher-skilled workers, who devote a greater share of their time to market work, enjoy disproportionately larger welfare gains from trade. The intensive margin of individual labor supply has long been set aside in quantitative trade analysis. As the labor-supply module we develop is portable across trade models, our findings suggest that this margin deserves greater attention — not only for its implications for aggregate welfare, but also for the distribution of gains across workers.

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A Appendix

A.1 Proof of Proposition 2

From Equations (3)–(8), it is readily checked that:

$$\frac{d\ln r}{d\ln\frac{w}{P}} = (\epsilon-1)(1-r), \tag{A.1}$$

$$\frac{d\ln V}{d\ln\frac{w}{P}} = r. \tag{A.2}$$

Thus, both $\frac{d\ln r}{d\ln\frac{w}{P}}$ and $\frac{d\ln y}{d\ln\frac{w}{P}}$ are positive when $\epsilon > 1$ and negative when $\epsilon < 1$; and $\frac{d\ln V}{d\ln\frac{w}{P}}$ is positive for all $\epsilon > 0$. Differentiating the above equations with respect to z yields:

$$\begin{aligned}
\frac{d}{dz}\frac{d\ln r}{d\ln\frac{w}{P}} &= -(\epsilon-1)\frac{dr}{dz} \\
&= -(\epsilon-1)^2(1-r)\frac{r}{z}, \\
\frac{d}{dz}\frac{d\ln V}{d\ln\frac{w}{P}} &= \frac{dr}{dz} \\
&= (\epsilon-1)(1-r)\frac{r}{z}.
\end{aligned}$$

We can thus conclude that $\frac{d\ln r}{d\ln\frac{w}{P}}$ is decreasing in z for all $\epsilon > 0$; and $\frac{d\ln V}{d\ln\frac{w}{P}}$ is increasing in z when $\epsilon > 1$, and decreasing in z when $\epsilon < 1$.

A.2 Proof of Lemma 3

From Equations (3), (4) and (8), we have

$$\begin{aligned}
R \equiv \int_1^\infty r(z)\,h(z)\,dz &= \kappa_z \int_1^\infty \frac{\left(\frac{\theta}{1-\theta}\right)^\epsilon\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-\kappa_z-2}}{1+\left(\frac{\theta}{1-\theta}\right)^\epsilon\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}}dz \\
Y \equiv Lw\overline{n}\int_1^\infty r(z)\,zh(z)\,dz &= Lw\overline{n}\kappa_z \int_1^\infty \frac{\left(\frac{\theta}{1-\theta}\right)^\epsilon\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1-\kappa_z}}{1+\left(\frac{\theta}{1-\theta}\right)^\epsilon\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}}dz \\
W &= L(1-\theta)^{\frac{\epsilon}{\epsilon-1}}\kappa_z\int_1^\infty (1-r(z))^{-\frac{1}{\epsilon-1}} z^{-\kappa_z-1}dz.
\end{aligned}$$

Observe that for all $t > 0$,

$$
\begin{aligned}
\lim_{z\to\infty} \frac{r(tz)\,h(tz)}{r(z)\,h(z)} &= \lim_{z\to\infty} t^{\epsilon-\kappa_z-2} \frac{1+\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}}{1+t^{\epsilon-1}\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}} \\
&= \begin{cases} t^{-\kappa_z-1} & \text{if } \epsilon > 1 \\ t^{-(\kappa_z-\epsilon)-2} & \text{if } \epsilon < 1 \end{cases} \\
\lim_{z\to\infty} \frac{r(tz)\,tzh(tz)}{r(z)\,zh(z)} &= t^{\epsilon-1-\kappa_z} \lim_{z\to\infty} \frac{1+\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}}{1+t^{\epsilon-1}\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}} \\
&= \begin{cases} t^{-\kappa_z} & \text{if } \epsilon > 1 \\ t^{-(\kappa_z-\epsilon)-1} & \text{if } \epsilon < 1 \end{cases} \\
\lim_{z\to\infty} \frac{(1-r(tz))^{-\frac{1}{\epsilon-1}}\,(tz)^{-\kappa_z-1}}{(1-r(z))^{-\frac{1}{\epsilon-1}}\,z^{-\kappa_z-1}} &= t^{-\kappa_z-1} \lim_{z\to\infty} \left(\frac{1-r(tz)}{1-r(z)}\right)^{\frac{1}{\epsilon-1}} \\
&= t^{-\kappa_z-1} \lim_{z\to\infty} \left[\frac{1+\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}}{1+t^{\epsilon-1}\left(\frac{\theta}{1-\theta}\right)^{\epsilon}\left(\frac{w}{P}\right)^{\epsilon-1} z^{\epsilon-1}}\right]^{-\frac{1}{\epsilon-1}} \\
&= \begin{cases} t^{-\kappa_z} & \text{if } \epsilon > 1 \\ t^{-\kappa_z-1} & \text{if } \epsilon < 1 \end{cases}.
\end{aligned}
$$

Accordingly, $r(z)\,h(z)$, $zr(z)\,h(z)$ and $(1-r(z))^{\frac{1}{\epsilon-1}}\,r(z)$ are all regularly varying in z with their exponents being less than -1 for all cases. It is well known that regularly varying functions are integrable if the exponent is less than -1. Thus, R, Y and W exist.

A.3 Proof of Proposition 4

Recall that the social welfare is given by:

$$W_k^{LS} = L_k\bar{n}\,(1-\theta)^{\frac{\epsilon}{\epsilon-1}}\, E\left[(1-r_k)^{-\frac{1}{\epsilon-1}}\right].$$

Using Equation (A.1), we have:

$$
\begin{aligned}
\frac{dW_k^{LS}}{d(w_k/P_k)} =& L_k\left(1-\theta\right)^{\frac{\epsilon}{\epsilon-1}}\bar{n}\frac{P_k}{w_k}\int_1^{\infty}\kappa_z\left[1-r\left(z;\frac{w_k}{P_k}\right)\right]^{-\frac{1}{\epsilon-1}}r\left(z;\frac{w_k}{P_k}\right)z^{-\kappa_z-1}dz \\
=& \frac{P_k}{w_k}W_k^{LS}\frac{\int_1^{\infty}\kappa_z\left[1-r\left(z;\frac{w_k}{P_k}\right)\right]^{-\frac{1}{\epsilon-1}}r\left(z;\frac{w_k}{P_k}\right)z^{-\kappa_z-1}dz}{\int_1^{\infty}\kappa_z\left[1-r\left(z;\frac{w_k}{P_k}\right)\right]^{-\frac{1}{\epsilon-1}}z^{-\kappa_z-1}dz} \\
=& \frac{P_k}{w_k}W_k^{LS}\frac{E\left(r_k\left[1-r_k\right]^{-\frac{1}{\epsilon-1}}\right)}{E\left(\left[1-r_k\right]^{-\frac{1}{\epsilon-1}}\right)} \\
=& \frac{P_k}{w_k}W_k^{LS}\frac{L_kE\left(\bar{n}\left(1-\theta\right)^{\frac{\epsilon}{\epsilon-1}}r_k\left[1-r_k\right]^{-\frac{1}{\epsilon-1}}\right)}{L_kE\left(\bar{n}\left(1-\theta\right)^{\frac{\epsilon}{\epsilon-1}}\left[1-r_k\right]^{-\frac{1}{\epsilon-1}}\right)} \\
=& \frac{P_k}{w_k}W_k^{LS}\frac{L_kE\left(r_kV_k\right)}{L_kE\left(V_k\right)} \\
=& \frac{P_k}{w_k}W_k^{LS}\frac{L_kE\left(r_kV_k\right)}{W_k^{LS}} \\
\Rightarrow d\ln W_k^{LS} =& \frac{L_kE\left(r_kV_k\right)}{W_k^{LS}}d\ln\frac{w_k}{P_k}.
\end{aligned}
\tag{A.3}
$$

Since the production side follows Eaton and Kortum (2002) with roundabout production, it follows that:

$$
d\ln W_k^{LS} = -\frac{L_kE\left(r_kV_k\right)}{W_k^{LS}}\frac{1}{\alpha\kappa_{\varphi}}d\ln\pi_{kk}.
$$

We can therefore decompose the welfare formula into an ACR statistic and a labor-supply factor:

$$
d\ln W_k^{LS} = \underbrace{-\frac{1}{\alpha\kappa_{\varphi}}d\ln\pi_{kk}}_{\textit{ACR statistic}} + \underbrace{\left[1-\frac{L_kE\left(r_kV_k\right)}{W_k^{LS}}\right]\frac{1}{\alpha\kappa_{\varphi}}d\ln\pi_{kk}}_{\textit{labor-supply factor (LSF)}}.
$$

The welfare gain relative to autarky is obtained by integrating the local formula with respect to π_{kk}, where autarky corresponds to $\pi_{kk} = 1$:

$$
\begin{aligned}
\int_{W_{k,autarky}^{LS}}^{W_k^{LS}} d\ln W_k &= \int_1^{\pi_{kk}} \frac{-1}{\alpha\kappa_\varphi} d\ln\pi + \int_1^{\pi_{kk}} \left[1 - \frac{L_k E(r_k V_k)}{W_k^{LS}}\right] \frac{1}{\alpha\kappa_\varphi} d\ln\pi \\
\Rightarrow \ln \frac{W_k^{LS}}{W_{k,autarky}^{LS}} &= -\frac{1}{\alpha\kappa_\varphi}\ln\pi_{kk} + \int_1^{\pi_{kk}} \left[1 - \frac{L_k E(r_k V_k)}{W_k^{LS}}\right] \frac{1}{\alpha\kappa_\varphi} d\ln\pi \\
\Rightarrow \widehat{W}_k^{LS} \equiv \frac{W_k^{LS}}{W_{k,autarky}^{LS}} &= \exp\left\{-\frac{1}{\alpha\kappa_\varphi}\ln\pi_{kk} + \int_1^{\pi_{kk}} \left[1 - \frac{L_k E(r_k V_k)}{W_k^{LS}}\right] \frac{1}{\alpha\kappa_\varphi} d\ln\pi\right\} \\
&= \pi_{kk}^{-\frac{1}{\alpha\kappa_\varphi}} \times \exp\left\{-\int_{\pi_{kk}}^1 \left[1 - \frac{L_k E(r_k V_k)}{W_k^{LS}}\right] \frac{1}{\alpha\kappa_\varphi} d\ln\pi\right\} \\
&\equiv ACR_k^{LS} \times LSF_k.
\end{aligned}
$$

A.4 *Deriving the Distribution of y*

In Proposition 1, we have shown that $\lim_{z\to\infty} y = \infty$ and $dy/dz > 0$. Since y is monotonic in z, the inverse relationship $y(z)$ is thus well defined and satisfies $\lim_{y\to\infty} z = \infty$. Therefore, the income distribution is defined on the support $[y_1, \infty)$ where $y_1 \equiv w\bar{n}\frac{\left(\frac{\theta}{1-\theta}\right)^\epsilon \left(\frac{w}{P}\right)^{\epsilon-1}}{1+\left(\frac{\theta}{1-\theta}\right)^\epsilon \left(\frac{w}{P}\right)^{\epsilon-1}}$. For the case where $\epsilon > 1$, note that the income can be restated as:

$$z = \frac{1}{r\bar{n}w} y.$$

Since y is monotonic in z, the inverse function $z(y)$ exists. Hence from dy/dz, we have:

$$\frac{dz(y)}{dy} = \frac{1}{\epsilon(1-r(y)) + r(y)} \frac{1}{r(y)\bar{n}w},$$

where $r(y) \equiv \frac{y}{w\bar{n}z(y)}$. Change of variable thus implies that:

$$f_y(y) = \frac{\kappa_z}{\epsilon[1-r(y)] + r(y)} [r(y)\bar{n}w]^{\kappa_z} y^{-\kappa_z-1}. \tag{A.4}$$

Note that Proposition 1 implies that an arbitrarily large y corresponds to an arbitrarily large z, which in turn leads to $r \to 1$. Therefore,

$$\lim_{y \to \infty} \frac{f_y(y)}{y^{-\kappa_z - 1}} = \kappa_z \left(\bar{n}w\right)^{\kappa_z}.$$

Hence, y's distribution follows a power law with a tail index κ_z.