

Estimating the Gains from Trade in Frictional Local Labor Markets *

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Abstract

We develop a theory and an empirical strategy to estimate the welfare gains of economic integration in economies with frictional local labor markets. The model yields a welfare formula that nests previous results in the literature and features an additional adjustment margin, via the employment rate, that generates new insights. We show that the quantitative impact of this new channel depends on the goods market structure and on the existence of firm heterogeneity. To obtain causal estimates of the two key structural parameters needed for the welfare analysis, the trade elasticity and the elasticity of substitution in consumption, we propose a theoretically-consistent identification strategy that exploits exogenous variation in production costs driven by differences in industrial composition across local labor markets. As an application, we exploit the unexpected fall of the Iron Curtain in 1990 to assess the quantitative importance of accounting for unemployment changes when computing the gains from trade across local labor markets in West Germany. Under monopolistic competition with free entry and firm heterogeneity, the median welfare gains in the frictional setting are 7% larger relative to the frictionless setting. The relative welfare gains are typically more modest under alternative market structures.

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1 Introduction

The looming global trade war has reinvigorated the public debate on the merits of international economic integration. The media focus and the political discourse revolve largely around the impact of international trade on labor market outcomes, particularly on jobs and wages. Interest in this topic among economists has not lagged behind. For example, recent empirical research examines the effects of import penetration and export expansion on unemployment and wages in US local labor markets ([Autor et al. \(2013\)](#), [Acemoglu et al. \(2016\)](#) [Pierce & Schott \(2016\)](#), and [Feenstra et al. \(2017\)](#)). Concurrently, the literature has increasingly acknowledged the prominent empirical role that individual firms play in shaping the impact of trade shocks on the labor market ([Card et al. \(2013\)](#), [Bloom et al. \(2016\)](#) and [Helpman et al. \(2017\)](#)).

What do these findings imply for the outcome of ultimate interest, social welfare? Perhaps surprisingly, we know relatively little about the quantitative impact of trade-induced changes in unemployment on welfare and the role that firms play. Our objective in this paper is to develop a theory and an empirical strategy to estimate the welfare gains from trade in economies with frictional local labor markets.

The theory introduces search frictions and wage bargaining into a general equilibrium model with two open economies -one of them composed of many local labor markets- and multiple industries populated by potentially heterogeneous firms. Our first contribution is to derive a simple formula that enables a comparison of the gains from trade across models with alternative market structures (perfect and monopolistic competition) featuring either frictional or frictionless labor markets. Our welfare formula nests well-known results in the literature and establishes new insights.

For a class of workhorse models that assume full employment of factor endowments, [Arkolakis et al. \(2012\)](#) –henceforth, ACR– show that the welfare gains from trade can be inferred from the share of expenditure on domestic goods and the trade elasticity; i.e. the elasticity of imports with respect to variable trade costs. In our model, however, labor market frictions imply that trade liberalization impacts real income via an additional channel, the employment rate. Importantly, the quantitative impact of this adjustment margin depends on the goods market structure and on the existence of firm heterogeneity. Under monopolistic competition with free entry, the welfare gains of changes in the employment rate depend inversely on the elasticity of substitution in consumption. Intuitively, for a given share of domestic expenditure, changes in the employment rate generate two effects: on aggregate income and on consumer prices. The second effect operates via product variety, driven by entry and exit decisions of firms responding to changes in aggregate expenditure. We show that, condi-

tional on the trade elasticity, the magnitude of this second effect depends on whether firms are homogeneous (Krugman (1980)) or heterogeneous (Melitz (2003) and Chaney (2008)). Moreover, when the measure of consumption goods is fixed, only the first effect remains active and our welfare formula nests two additional cases of interest: monopolistic competition with restricted entry and perfect competition (i.e. a multi-industry extension of Heid & Larch (2016), for the Armington (1969) model with search and bargaining frictions).

Our second contribution is to obtain causal estimates of the two structural parameters that regulate the welfare gains from trade in our model, the elasticity of substitution and the trade elasticity. As we discuss below, these parameters also play crucial roles in a wide range of models and applications in the literature and hence our empirical methodology can, in principle, be applied well beyond the scope of this paper. We show that the two key structural parameters can be identified from two wage elasticities: the wage elasticity of firm-level domestic revenue and the wage elasticity of bilateral trade flows in a gravity equation that holds at the local-labor-market level. To address the endogeneity of wages in the two estimating equations, we propose an identification strategy that exploits exogenous variation in production costs driven by differences in industrial composition across local labor markets. Strategic bargaining between firms and workers implies that the local equilibrium wage depends on the industrial composition of the labor market: local labor markets with greater concentration of high-paying industries improve workers' outside option and, *ceteris paribus*, imply relatively higher costs for producers in any given industry. This property of the model naturally leads us to use Bartik-style instruments for the local wage in the estimating equations.

We implement our empirical methodology using firm-level data for Germany, spanning 24 local labor markets and 58 industries during 1993-2010. The Bartik instruments are computed from a weighted average of national-level industrial wage premia, with weights reflecting local industry employment composition in the initial year. Identification, therefore, stems from within-industry, across-city variation in local wages. For the instruments to be valid, we require shocks to local labor markets as well as technological innovations to be independent from local industrial composition in employment in the initial year. The validity of our instruments therefore hinges on the exogeneity of the base-period local industrial employment shares (Goldsmith-Pinkham et al., 2017). To evaluate the quality of our identification strategy, we propose a series of data-driven tests that consist in assessing the relevance of our instruments and the correlation of our instruments with observables in the base year. We also perform Hansen's test of overidentifying restrictions. Overall, the results from these tests support our instrumental variable strategy and the estimates we obtain are remarkably stable over a variety of specifications.

We estimate wage elasticities of 7.5 and 0.2 in the gravity and domestic revenue equations, respectively. From these, we recover an elasticity of substitution in consumption of 1.2 and a trade elasticity that ranges from 1.25 to 6.5, depending on the underlying micro details of the model. We find that OLS produces substantial biases, particularly in the gravity equation; when estimated by OLS, the wage elasticities are equal to 2 and 0.4 in the gravity and domestic revenue equations, respectively. Moreover, since welfare is inversely related to the elasticity of substitution, our relatively low IV estimate of 1.2 hints at the possibility that omitting labor market frictions and firm heterogeneity might lead to a substantial underestimation of the welfare gains from trade.

Finally, we exploit the unexpected fall of the Iron Curtain in 1990 as a natural experiment to assess the quantitative importance of accounting for firm heterogeneity and changes in unemployment when computing the gains from trade for local labor markets in West Germany. Our ex-post welfare evaluations take the trade elasticity and changes in local employment rates, domestic trade shares and industry composition as given by the data and ask: how do the measured gains from trade between 1989 and 1991 differ when changes in the employment rate are accounted for? The answer depends on the underlying market structure and on the existence of firm heterogeneity. Indeed, under monopolistic competition with free entry and firm heterogeneity, welfare gains in the frictional setting are 7% greater than those predicted by ACR's formula, for the median local labor market in West Germany. In contrast, accounting for changes in the employment rate in frameworks with homogeneous firms, monopolistic competition with restricted entry or perfect competition yield gains that are around 1% larger.

The paper belongs to a growing literature that studies the interrelationship between labor market outcomes and international trade. Our theoretical framework is related to papers that introduce search frictions, as in [Pissarides \(2000\)](#), into the heterogeneous firms model of [Melitz \(2003\)](#). [Helpman & Itskhoki \(2010\)](#) and [Helpman et al. \(2010\)](#) theoretically examine the impact of trade liberalization on unemployment, wages and welfare but do not attempt a quantitative assessment of the gains from trade. [Helpman et al. \(2017\)](#) structurally estimate their model but focus on wage inequality rather than welfare. Our model departs from [Felbermayr et al. \(2011\)](#) by considering asymmetric locations in terms of trade costs and distributions of firm productivity. This feature allows us to escape from a separability result established in Lemma 1 of [Felbermayr et al. \(2011\)](#), under which productivity cutoffs and industry exports do not depend on local wages. In contrast, that link plays a central role in our empirical strategy. [Świącki \(2017\)](#) extends ACR's welfare formula in a Ricardian model that features labor misallocation across industries. Since full employment still prevails in equilibrium, welfare changes are independent of the employment rate – whereas their

dependence is a key feature of our theory.

A widely popular approach to estimating the trade elasticity relies on the gravity equation for bilateral trade. In a broad class of models that comply with structural gravity assumptions, [Head et al. \(2014\)](#) show that the trade elasticity can, in principle, be identified from variation in either bilateral trade costs (e.g. distance or tariffs) or, closer to our approach, export “competitiveness” (e.g. wages or productivity). In both cases, the central empirical challenge is finding reliable instruments that can be excluded from the gravity equation. Similarly, the standard approach to estimating elasticities of substitution, developed by [Feenstra \(1994\)](#), [Broda & Weinstein \(2006\)](#) and [Soderbery \(2015\)](#), requires no correlation between the error terms in bilateral import demand and export supply equations, a restrictive yet necessary assumption in the absence of exogenous supply shifters.

The novelty of our empirical approach is to propose model-based, Bartik-style instruments that exploit wage and employment variation across industries and local labor markets to identify the elasticity of substitution and the trade elasticity. Moreover, since our approach relies exclusively on within-country variation, the resulting estimates are less prone to identification challenges that plague cross-country estimation of the gravity equation, including reverse causality due to endogenous tariff protection and omitted variable bias due to unmeasured institutional features of countries that are potentially correlated with trade flows, tariffs and factor prices. As long as trade policy and institutions do not vary across local labor markets within a country, their effects can be controlled for with an appropriate set of fixed effects.

The remainder of the paper is organized as follows. Section 2 develops the theoretical framework. Section 3 discusses the empirical strategy. Section 4 describes the data. Section 5 reports the estimation results. Section 6 presents our counterfactual exercises. The final section concludes. The Appendix contains all theoretical derivations and additional empirical results.

2 Theoretical Framework

2.1 Setup

There are two countries, Home and Foreign. Home (Germany) is composed of local labor markets called cities, indexed by $c \in \{1, \dots, C\}$. Since we do not observe export destinations in the data, we assume that Foreign is a single economy with no internal barriers (the extension is straightforward). We will use subscript n to denote a particular location irrespective of its country and subscript F when referring specifically to Foreign.

Demand. Each location n is populated by a continuum of infinitely-lived individuals of mass \bar{L}_n with identical risk-neutral preferences, represented by a time-separable and stationary Cobb-Douglas instantaneous utility function defined over the consumption of I differentiated goods. Time is discrete and denoted by $t \geq 1$. The normative representative consumer in market n maximizes $\sum_{t=1}^{\infty} \prod_{i=1}^I (Y_{int})^{\alpha_i} / (1 + \rho)^t$, where α_i is the share of expenditure on good i , $\rho > 0$ is the discount factor and

$$Y_{int} = \left[\int_{\omega \in \Omega_{int}} q_{int}(\omega)^{\frac{\sigma_i-1}{\sigma_i}} d\omega \right]^{\frac{\sigma_i}{\sigma_i-1}}, \quad \sigma_i > 1,$$

is a CES index of the aggregate consumption $q_{int}(\omega)$ of varieties $\omega \in \Omega_{int}$ of good i . σ_i is the elasticity of substitution. The set Ω_{int} may contain varieties produced in any city (intranational trade) and Foreign (international trade). The composition and measure of Ω_{int} is determined endogenously if and only if there is free entry.

In a standard setting with sequential trading in complete one-period Arrow securities, the aggregate consumption and equilibrium price of every differentiated good are time-invariant if the aggregate consumer income is time-invariant. As in [Hopenhayn \(1992\)](#) and [Melitz \(2003\)](#), our analysis is restricted to stationary equilibria and thus we henceforth suppress the time subscript to ease notation.¹ For good i in market n , the aggregate demand for variety ω with price $p_{in}(\omega)$ is

$$q_{in}(\omega) = A_{in} p_{in}(\omega)^{-\sigma_i}, \quad (1)$$

where $A_{in} = X_{in} P_{in}^{\sigma_i-1}$ is the demand shifter, X_{in} is total expenditure and

$$P_{in} = \left[\int_{\omega \in \Omega_{in}} p_{in}(\omega)^{1-\sigma_i} d\omega \right]^{\frac{1}{1-\sigma_i}}$$

is the price index.

Product Markets. For ease of exposition, we focus on analyzing a monopolistically competitive setting with free entry and heterogeneous firms. We briefly discuss the special cases of homogeneous firms with free or restricted entry and defer the details to the Appendix. The latter also contains a complete treatment of the case of perfect competition in the goods market under constant returns to scale.

¹At this point, the reader may wonder about the rationale for setting up a dynamic, rather than static, model if the analysis is restricted to stationary equilibria. Essentially, the dynamic setting allows us to have a microfounded outside option for workers that depends on the probability of future transitions to alternative jobs in the economy. This property plays a key role in our empirical strategy. In contrast, in a static search framework outside options do not depend on the industrial composition of the economy.

A competitive fringe of risk-neutral firms can acquire a blueprint to produce a unique variety of good i in city c by incurring a sunk per-period investment f_{ic}^E that terminates in any period with exogenous probability δ_c . To serve any market n , the firm must incur an additional fixed cost f_{icn} per period and a variable iceberg trade cost, such that τ_{icn} units of the firm's output must be produced per unit that arrives in market n . We assume $\tau_{icn} \geq \tau_{icc}$ and that variable trade costs respect the triangular inequality for any three locations. Fixed and entry costs are measured in units of (non-production) workers hired in the domestic labor market.

Upon entry (but before incurring any fixed and variable costs), the firm discovers the time-invariant productivity of its production workers, denoted φ , an independent draw from a known distribution $G_{ic}(\varphi)$ with positive support. Firms thus operate under constant but heterogeneous marginal returns to the variable input. All firms with the same productivity behave symmetrically in equilibrium, hence we index firms and varieties by φ from now onward. Prior to the beginning of the following period, the firm is hit by an i.i.d. shock that forces it to exit with probability δ_c .

For the case of homogeneous firms, we consider a degenerate productivity distribution and set $f_{ic}^E = f_{icn} = 0$. In addition, under free entry, there is a fixed startup cost f_{ic} that depends on the industry and location of the producer. Alternatively, under restricted entry, the mass of producers is exogenous.

Labor Market Frictions and Bargaining. The labor market in city c is characterized by search frictions and wage bargaining, modeled as in [Felbermayr et al. \(2011\)](#). In each period, firms post vacancies and all unemployed workers search. Matching is random and determined by a linearly homogeneous matching function. $m_c(\theta_c)$ denotes the vacancy filling rate, a decreasing function of the vacancy-unemployment ratio (or labor market tightness) θ_c . The job finding rate is $\theta_c m_c(\theta_c)$. Letting k_{ic} denote the cost of posting vacancies, the recruitment cost per matched worker is $[k_{ic}/m_c(\theta_c)]$. Matched workers enter production in the following period. Before production takes place, wages are determined by an intra-firm bargaining process that assumes the absence of binding employment contracts, as in [Stole & Zwiebel \(1996\)](#).² All payments are made at the end of each period. Workers earn no income while unemployed.

²Wage agreements can be renegotiated any time before production begins. A firm may fire an employee or the latter may quit, in which case the worker immediately returns to the unemployment pool. During the bargaining process, the firm cannot recruit additional workers. Once production begins, wage agreements become binding. In equilibrium, wages are immune to intra-firm pairwise renegotiations.

2.2 The Firm's Problem

We analyze the problem of a firm with productivity φ producing good i in city c . As anticipated, we restrict attention to stationary equilibria in which firm productivity distributions and all aggregates remain constant through time. We proceed in three steps. First, taking employment and export decisions as given, the firm seeks to maximize revenue by allocating output optimally across destinations. This is a static problem that yields firm revenue as a function of employment. Second, the firm solves a dynamic vacancy posting problem to determine the profit-maximizing employment level, anticipating the effect of this decision on the wage bargaining outcome. Finally, the firm makes entry and exit decisions, supplying all locations that generate non-negative profits.

The (Conditional) Revenue Function. A firm with productivity φ and l production workers allocates output to equalize marginal revenues across any two markets it serves. With CES demand (1), the c.i.f. price in market n is then proportional to the domestic price; i.e., $p_{icn}(\varphi) = \tau_{icn}p_{icc}(\varphi)$. This property enables a convenient aggregation of destination-specific revenues that allows us to express the firm's total revenue, $r_{ic}(l; \varphi)$, as a function of l :

$$r_{ic}(l; \varphi) = \left[\sum_n I_{icn}(\varphi) A_{in} (\tau_{icn})^{1-\sigma_i} \right]^{\frac{1}{\sigma_i}} (l\varphi)^{\frac{\sigma_i-1}{\sigma_i}}, \quad (2)$$

where $I_{icn}(\varphi)$ is an indicator function equal to one when the firm supplies good i in market n .

Optimal Vacancy Posting. Firms post vacancies, denoted v , in order to maximize the present value of expected profits. Firm φ currently employing l production workers solves:

$$\begin{aligned} \Pi_{ic}(l; \varphi) = \max_v \frac{1}{1+\rho} \left\{ r_{ic}(l; \varphi) - w_{ic}(l; \varphi)l - w_{ic} \sum_n I_{icn}(\varphi) f_{icn} - k_{ic}v + (1 - \delta_c) \Pi_{ic}(l'; \varphi) \right\}, \\ \text{s.t. } l' = l + m_c(\theta_c)v, \end{aligned} \quad (3)$$

where l' is the mass of production workers in the following period. $w_{ic}(l; \varphi)$ is the wage bargaining outcome, characterized below. Note that we allow the firm to internalize the effect of employment size on the cost of recruiting production workers. For tractability, however, we assume that the firm takes the wage of non-production workers w_{ic} as given

when solving (3) and impose $w_{ic} = w_{ic}(l; \varphi)$ in equilibrium.³

The first-order condition in problem (3),

$$(1 - \delta_c) \frac{\partial \Pi_{ic}(l; \varphi)}{\partial l} = \frac{k_{ic}}{m_c(\theta_c)}, \quad (4)$$

equates the expected marginal profit of hiring an additional worker to the recruitment cost per worker. Equation (4) has two important implications. First, optimal employment size is independent of current employment l and constant over time as long as the firm is not forced to exit the market. In other words, employment in a firm that starts with no workers reaches its optimal long-run level in the following period.⁴ Second, the marginal profit of hiring an additional worker, $\partial J_{ic}(l; \varphi)/\partial l$, is equalized across firms, despite heterogeneity in labor productivity. This result plays an important role in the outcome of the wage bargaining process.

Bargaining. The firm and its workers engage in strategic wage bargaining as in [Stole & Zwiebel \(1996\)](#), a generalization of Nash bargaining to the case of multiple workers. The value of unemployment, denoted U_c , depends on the industrial composition of the labor market (quality of jobs) and on the tightness of the labor market (quantity of jobs). Letting η_{ic} denote the share of employment of industry i in city c ,

$$\rho U_c = \frac{\theta_c m_c(\theta_c)}{\rho + \delta_c} \sum_i \eta_{ic} (w_{ic} - \rho U_c). \quad (5)$$

The value of employment in a firm with productivity φ and l production workers, denoted $E_{ic}(l; \varphi)$, satisfies

$$(\rho + \delta_c) [E_{ic}(l; \varphi) - U_c] = w_{ic}(l; \varphi) - \rho U_c. \quad (6)$$

The surplus splitting rule that solves the bargaining game can then be written as:

$$(1 - \beta_i) [E_{ic}(l; \varphi) - U_c] = \beta_i \frac{\partial J_{ic}(l; \varphi)}{\partial l}, \quad (7)$$

³This myopic assumption turns out to be consistent with the bargaining outcome; i.e. we show below that wages are equalized across firms in any city-industry cell. Moreover, the assumption ensures that we can obtain a closed-form solution for $w_{ic}(l; \varphi)$ in the bargaining game while adhering to the usual practice in the trade literature of measuring fixed costs in terms of domestic labor (e.g. [Melitz \(2003\)](#) and [Melitz & Redding \(2014\)](#)).

⁴The absence of transitional dynamics ensures that the model remains analytically tractable. This property is particularly crucial in our derivation of sufficient statistics for welfare changes due to trade liberalization.

where $\beta_i \in (0, 1)$ denotes the bargaining power of workers.⁵ Combining the revenue function (2), the envelope condition from (3), the first-order condition (4) and the value of employment (6), we can express the surplus-splitting rule (7) as a differential equation for the wage schedule. Its solution is

$$w_{ic} = \rho U_c + \frac{\beta_i}{(1 - \beta_i)} \left(\frac{\rho + \delta_c}{1 - \delta_c} \right) \frac{k_{ic}}{m_c(\theta_c)}. \quad (8)$$

Three remarks are in order. First, the equilibrium wage does not vary across firms within city-industry cells. Intuitively, firms adjust their labor force until the marginal profit of hiring an additional worker is equalized across firms. By (7), this equalizes the value of employment across firms. Wage equalization then follows from (6). Second, the city-industry wage w_{ic} depends on the industrial composition of the local labor market, via the worker's outside option U_c . By (5), cities with greater concentration of high-wage industries improve workers' outside option and display, *ceteris paribus*, a higher bargained wage in any given industry i . Finally, note that inter-industry wage differentials within local labor markets are driven by cross-industry variation in bargaining power (β_i) and costs of posting vacancies (k_{ic}).

Firm-level Outcomes. The stationarity of the vacancy posting problem implies that firms face a constant cost per employee each period, denoted μ_{ic} , equal to the wage plus the recruitment cost expressed on a per-period basis. In the Appendix, we show that

$$\mu_{ic} = w_{ic} + \left(\frac{\rho + \delta_c}{1 - \delta_c} \right) \frac{k_{ic}}{m_c(\theta_c)}. \quad (9)$$

Henceforth, we refer to μ_{ic} as the *cost of labor* in industry i of city c .

Under CES demand, the profit maximizing revenue per worker is a fixed proportion $(\sigma_i - \beta_i) / (\sigma_i - 1)$ of the cost of labor.⁶ This property enables closed-form solutions for all firm-level equilibrium outcomes in terms of the cost of labor μ_{ic} and demand shifters A_{in} . In particular, the firm's per-period revenue, denoted $r_{ic}(\varphi)$, can be written as

$$r_{ic}(\varphi) = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} \left[\sum_n I_{icn}(\varphi) A_{in} (\tau_{icn})^{1 - \sigma_i} \right] \left(\frac{\varphi}{\mu_{ic}} \right)^{\sigma_i - 1}. \quad (10)$$

Note that the partial elasticity of firm-level revenue with respect to the local cost of labor is

⁵Note that the marginal surplus of the firm, $\partial J_{ic}(l; \varphi) / \partial l$, accounts for the impact of employing an additional worker on the wage of the remaining production workers, a key feature of [Stole & Zwiebel \(1996\)](#). Also note that the surplus is expressed in units of the numeraire.

⁶This is a usual property in static monopolistic competition models with CES demand and competitive labor markets that leads to a constant mark-up pricing rule. In the Appendix, we verify that it also holds in the current stationary setup with search and bargaining frictions.

fully determined by the elasticity of substitution, a property that we exploit in the empirical analysis.

In turn, the per-period profit (gross of the entry cost) is

$$\pi_{ic}(\varphi) = \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) r_{ic}(\varphi) - \mu_{ic} \sum_n I_{icn}(\varphi) f_{icn}. \quad (11)$$

The per-period profit generated by entering any particular market n is computed by switching the corresponding entry decision on ($I_{icn}(\varphi) = 1$) and off ($I_{icn}(\varphi) = 0$) in (60). The existence of fixed costs of market access and the monotonicity of revenue in firm productivity imply that there is a cutoff productivity level, denoted φ_{icn}^* , such that a firm with productivity φ enters market n if and only if $\varphi \geq \varphi_{icn}^*$. The cutoff satisfies

$$\left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) r_{icn}(\varphi_{icn}^*) = \mu_{ic} f_{icn} \quad \Leftrightarrow \quad \Lambda_i^0 A_{in} (\tau_{icn})^{1-\sigma_i} (\varphi_{icn}^*)^{\sigma_i-1} (\mu_{ic})^{-\sigma_i} = f_{icn}, \quad (12)$$

where $r_{icn}(\varphi)$ denotes the sales of firm φ in market n and $\Lambda_i^0 > 0$ is a function of parameters σ_i and β_i .⁷

It is worth highlighting that with symmetric cities/locations, productivity cutoffs would be independent of the tightness in the labor market, a separability result established in [Felbermayr et al. \(2011\)](#).⁸ By relaxing symmetry across cities, we can circumvent this result and allow the cost of labor (and hence outside options and the industrial composition of the labor market) to have a feedback effect on equilibrium productivity distributions and firm selection into export markets. As we show below, this property plays a crucial role in our empirical approach to identifying key structural parameters that regulate the gains from economic integration in our model.

2.3 Gravity

In this section, we show that the model delivers a sectoral gravity equation relating bilateral trade flows to the cost of labor at the city level when firm productivity follows a Pareto distribution. In the empirical analysis, we use the gravity equation to estimate key structural parameters that regulate the welfare gains of economic integration.

⁷More specifically, $\Lambda_i^0 = (1 - \beta_i) (\sigma_i - 1)^{\sigma_i-1} / (\sigma_i - \beta_i)^{\sigma_i}$.

⁸To see this, assume for a moment that countries are symmetric. In this case, equation (12) pins down the ratio of the export and domestic cutoffs in any industry independently of the cost of labor. In turn, it can be shown that the (industry-specific) free entry condition provides a second equation for the two productivity cutoffs that is independent of the cost of labor (e.g. the next section illustrates this for the case of Pareto productivity distributions).

We start by aggregating firm sales in industry i from city c to location n , denoted X_{icn} . Letting M_{ic}^e denote the mass of *entrants* in cell ic , we have $X_{icn} = M_{ic}^e \int_{\varphi_{icn}^*}^{\infty} r_{icn}(\varphi) dG_{ic}(\varphi) / \delta_c$.⁹ To eliminate M_{ic}^e from the gravity equation, we focus on the share of exports in sectoral revenue, X_{icF} / R_{ic} , where $R_{ic} \equiv \sum_n X_{icn}$. Assume that $G_{ic}(\varphi)$ follows a Pareto distribution with positive lower bound $\varphi_{\min,ic}$ and shape parameter κ_i , where $\kappa_i > \sigma_i - 1$.¹⁰ Using equation (10), we obtain

$$\frac{X_{icF}}{R_{ic}} = \frac{(\varphi_{icF}^*)^{-\kappa_i} f_{icF}}{\sum_n (\varphi_{icn}^*)^{-\kappa_i} f_{icn}}. \quad (13)$$

We can simplify this expression using the free entry and cutoff conditions. For cell ic , the free entry condition equates the expected per-period profit for entrants to the expected per-period entry cost, i.e. $\int_0^{\infty} \pi_{ic}(\varphi) dG_{ic}(\varphi) = \mu_{ic} f_{ic}^E$. Under Pareto productivity, this fixes the denominator of (13).¹¹ Using the export cutoff condition (12) to eliminate φ_{icF}^* from the numerator of (13), the latter becomes

$$\frac{X_{icF}}{R_{ic}} = \Lambda_i^1 (f_{ic}^E)^{-1} (f_{icF})^{1 - \frac{\varepsilon_i}{\sigma_i - 1}} \left(\frac{\varphi_{\min,ic}}{\tau_{icF}} \right)^{\varepsilon_i} (A_{iF})^{\frac{\varepsilon_i}{\sigma_i - 1}} (\mu_{ic})^{-\frac{\varepsilon_i \sigma_i}{\sigma_i - 1}}, \quad (14)$$

where $\varepsilon_i \equiv \kappa_i$ is the *trade elasticity*; i.e. the partial elasticity of the export share with respect to the variable trade cost. $\Lambda_i^1 > 0$ is a function of parameters β_i , ε_i , σ_i and ρ .¹²

Conditional on the demand shifter in Foreign, A_{iF} , a higher cost of labor in industry i in city c reduces its share of exports of this good by tightening firm selection into the export market.¹³ The partial elasticity of the export share with respect to the cost of labor depends on two structural parameters, the elasticity of substitution σ_i and the trade elasticity ε_i .

⁹This expression relies on the aggregate stability condition, which requires that the mass of successful entrants $(1 - G_{ic}(\varphi_{icc}))M_{ic}^e$ exactly replaces the mass $\delta_c M_{ic}$ of producers who exit in each period.

¹⁰Note that we allow for Ricardian comparative advantage by letting the lower bound vary across cities and industries.

¹¹Under Pareto productivity, the free entry condition in cell ic simplifies to

$$\left(\frac{\sigma_i - 1}{\kappa_i - \sigma_i + 1} \right) (\varphi_{\min,ic})^{\kappa_i} \sum_n (\varphi_{icn}^*)^{-\kappa_i} f_{icn} = f_{ic}^E.$$

¹²Specifically, $\Lambda_i^1 = \left(\frac{\sigma_i - 1}{\varepsilon_i - \sigma_i + 1} \right) \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right)^{\frac{\varepsilon_i \sigma_i}{\sigma_i - 1}}$.

¹³Note that if μ_{ic} increases (e.g. due to higher bargained wages or recruitment costs), not all cutoffs φ_{icn}^* in a given cell ic can increase because that would reduce profitability in all destinations, violating the free entry condition. However, if Foreign's demand shifter does not change (e.g. if the city is small relative to the rest of the world), the export cutoff φ_{icF}^* indeed increases, reducing the city's export share of good i . This observation underscores the importance of controlling for the demand shifter of the export market when estimating the elasticity of the export share with respect to the cost of labor.

2.4 Welfare

In this section, we study the consequences of economic integration on the welfare of consumers in city c . Holding intracity variable trade costs constant, we analyze otherwise arbitrary shocks to variable trade costs, therefore spanning various forms of intranational and international integration. We show that, when frictions in the local labor market are small, the welfare consequences of economic integration can be approximated by a parsimonious generalization of ACR's welfare formula that features an additional adjustment margin, via the employment rate.

Consumer preferences satisfy the Gorman form, hence there exists a normative representative consumer in every city. Recall that aggregate consumption and aggregate income are constant in any stationary equilibrium. Therefore the indirect utility of the representative consumer in city c , denoted V_c , is proportional to the per-period real income in the city:

$$V_c = \rho^{-1} \left(\prod_{i=1}^I (\alpha_i)^{\alpha_i} \right) \frac{\sum_{i=1}^I L_{ic} w_{ic}}{\prod_{i=1}^I (P_{ic})^{\alpha_i}},$$

where L_{ic} is the mass of workers employed in industry i .¹⁴

Consider the effects of an arbitrary shock to the vector of variable trade costs, $\{\tau_{ivn}\}$ for any industry i and any two different locations n and v , on the welfare of city c . For any endogenous variable x , let \dot{x} denote the ratio of x after the shock to x before the shock; i.e. the proportional change in the stationary equilibrium value of x . For analytical tractability, suppose that the cost of posting vacancies in city c , k_{ic} , is small in all industries. Equations (8) and (9) imply that the cost of labor in any industry is approximately equal to the average wage in the city, denoted w_c ; that is, $\mu_{ic} \approx w_c$ for all i . Then

$$\dot{V}_c \approx \frac{\dot{e}_c \dot{w}_c}{\prod_{i=1}^I (\dot{P}_{ic})^{\alpha_i}}, \quad (15)$$

where e_c is the employment rate in city c , i.e. $e_c = \sum_i L_{ic} / \bar{L}_c$. Note that \dot{V}_c is the equivalent variation expressed as a fraction of the per-period income in the initial equilibrium.

The price index of any good i in city c depends on trade costs, costs of labor, technology and mass of producers of good i in all other locations that supply city c . We follow ACR and use city c 's domestic trade share, $\lambda_{icc} \equiv X_{icc} / \sum_n X_{icn}$, as a sufficient statistic for the impact of all these external effects on P_{ic} . In the Appendix, we show that the proportional change in the price index following the shock to variable trade costs is approximately

¹⁴Under MC-RE, real income also includes positive aggregate profits. See Appendix.

$$\dot{P}_{ic} \approx \left(\frac{\dot{\lambda}_{icc}}{\dot{\eta}_{ic}} \right)^{\frac{1}{\varepsilon_i}} (\dot{e}_c)^{-\Upsilon_i} \dot{w}_c, \quad (16)$$

where η_{ic} is industry i 's share of employment in city c and Υ_i is a parameter that depends on the micro details of the model. In particular,

$$\Upsilon_i = \begin{cases} \frac{1}{\sigma_i - 1}, & \text{under MC-FE-HET,} \\ \frac{1}{\varepsilon_i}, & \text{under MC-FE-HOM,} \\ 0, & \text{under PC or MC-RE,} \end{cases}$$

where MC-FE-HET and MC-FE-HOM denote monopolistic competition settings with free entry and either heterogeneous or homogeneous firms, respectively. MC-RE denotes monopolistic competition with restricted entry and PC denotes the multi-industry extension of the perfectly competitive Armington model with search frictions of [Heid & Larch \(2016\)](#).

Equations (A.8) and (15) show that, conditional on $\dot{\lambda}_{icc}$, $\dot{\eta}_{ic}$ and ε_i , changes in the employment rate \dot{e}_c impact both aggregate income and consumer prices. The latter operates via product variety as a function of the structure of the goods market and the existence of firm heterogeneity, as summarized by Υ_i . Under monopolistic competition with free entry, product variety is driven by entry and exit decisions of firms responding to changes in aggregate expenditure. Conditional on the trade elasticity, however, the magnitude of this effect depends on whether firms are homogeneous or heterogeneous. Moreover, under perfect competition or monopolistic competition with restricted entry, the measure of consumption goods is fixed and hence changes in aggregate expenditure have no effects on product variety.

Substituting (A.8) in (15), we obtain the main result of this section.

Proposition 1. *Suppose that the cost of posting vacancies, k_{ic} , is small in all industries of city c . Then the welfare gains in city c associated with an arbitrary shock to the vector of variable trade costs can be approximated as*

$$\dot{V}_c \approx (\dot{e}_c)^{1 + \sum_{i=1}^I \alpha_i \Upsilon_i} \prod_{i=1}^I \left(\frac{\dot{\lambda}_{icc}}{\dot{\eta}_{ic}} \right)^{-\frac{\alpha_i}{\varepsilon_i}}. \quad (17)$$

Expression (A.9.6) nests the multi-sector welfare formula derived by ACR for versions of the models considered in this paper that feature frictionless labor markets. In these cases, $\dot{e}_c = 1$ because variable trade costs have no impact on aggregate employment. In our theory, however, frictions in the labor market generate equilibrium unemployment and hence enable an additional adjustment margin for welfare changes, via the employment rate. Note that quantifying welfare changes in the standard case of frictionless labor markets requires

estimating two structural parameters per industry, the expenditure share α_i and the trade elasticity ε_i . This also applies to (A.9.6) except under MC-FE-HET, which additionally requires an estimate of the elasticity of substitution σ_i , the crucial parameter that regulates the impact of employment rate changes on welfare.

3 Empirical Strategy

The goal of this section is to develop the methodological steps required to take our welfare formula to the data. Equation (A.9.6) depends on four variables that are, in principle, observable (the employment rate in city c , the share of industrial employment in city c , the domestic trade share of city c and the share of expenditures on good i) and on two structural parameters (σ_i and ε_i).¹⁵ Therefore, estimating the gains from trade first requires recovering these two structural parameters. In a nutshell, we propose identifying them from the estimated unit-cost elasticities of the firm-level domestic revenue and local gravity equations. In what follows, we discuss this empirical strategy in detail.

In the model, the elasticity of substitution and the trade elasticity are industry-specific. To reduce the estimation demands on our dataset, however, we will estimate values of these parameters that are constant across industries and over time, which we refer to simply as σ and ε .¹⁶

To make progress toward an empirical specification of our main equations, we first use equation (9) to establish the log-linear approximation to the unobservable cost of labor. We choose to take the approximation around the point where the cost of posting vacancies is small and obtain:

$$\ln \mu_{ic} = \ln w_{ic} + \psi \frac{k_{ic}}{\bar{w}}, \quad (18)$$

where ψ is a constant parameter and the constant \bar{w} denotes the cost of labor at the point where we take the linear approximation.¹⁷

Expression (18) allows us to rewrite the gravity equation (14) as a linear function of the observable industry-city specific log wage. Taking logs, adding time subscripts (since we use

¹⁵Note that our empirical strategy does not rely on direct observation of the four above-mentioned variables. In our empirical application, for example, we only observe the employment rate in city c and the share of industrial employment in city c . Observability is a dataset-specific constraint that will nevertheless determine the set of counterfactual exercises that may be implemented in a given dataset.

¹⁶Our empirical strategy, however, fully applies in the absence of this restriction because it exploits cross-city rather than cross-industry variation to identify the key structural parameters.

¹⁷Specifically, $\psi = \left(\frac{\rho+\delta}{1-\delta}\right) \frac{1}{m(\theta)}$, where the vacancy-filling rate $m(\theta)$ is constant around the point where k_{ic} is small. Details of the linear approximation of the unit cost can be found in Appendix B.1.

data at the city-industry-year level) and first-differencing over time yields:

$$\Delta \ln \left(\frac{X_{icFt}}{R_{ict}} \right) = \Delta d_{it} + \phi_1 \Delta \ln w_{ict} + \Delta u_{ict}^G, \quad (19)$$

where ϕ_1 is the wage elasticity of the local gravity equation; e.g. $\phi_1 = -\frac{\kappa\sigma}{(\sigma-1)}$, under MC-FE-HET.¹⁸ The term Δd_{it} is a full set of industry-year effects that captures changes in the demand shifter in Foreign, A_{iFt} . Moreover, the inclusion of Δd_{it} allows to control for time-varying industry-specific unobserved variables, such as changes in the industry component of the cost of posting vacancies, fixed costs, trade policy, non-tariff barriers to trade or (national-level) comparative advantage. The error term, Δu_{ict}^G , is a log-linear function of shifts in industry-city-specific residual components in k_{ict} , f_{ic}^E , f_{icF} , $\varphi_{\min,ic}$ and τ_{icF} , which are collected in the error term after controlling for Δd_{it} . Δ eliminates time-invariant industry-city terms; e.g. local or industrial fixed comparative advantages stemming from geography, institutions or technology.

The domestic revenue equation at the firm level can be obtained similarly using equation (10) together with equation (18):

$$\Delta \ln r_{ict}(\varphi) = \Delta d_{it} + \phi_2 \Delta \ln w_{ict} + T(\varphi) + \Delta u_{ict}^R(\varphi), \quad (20)$$

where $\phi_2 = 1 - \sigma$ and $T(\varphi)$ denote firm fixed effects that capture firm-specific linear trends in productivity (i.e. $(\sigma - 1)\Delta \ln \varphi_t$). $\Delta u_{ict}^R(\varphi)$ is an error term which contains movements in industry-city residual components in the local log demand shifter A_{ict} and the cost of posting vacancies k_{ict} .¹⁹

Identification of ϕ_1 and ϕ_2 requires isolating variation in industry-city log wages that is orthogonal to the composite error terms, Δu_{ict}^G and $\Delta u_{ict}^R(\varphi)$, respectively. In this framework that incorporates search and bargaining, wages are necessarily endogenous because the wage, revenue and gravity equations all contain changes in the idiosyncratic component of the vacancy posting cost in the error term. Thus, estimating equations (19) and (20) by ordinary

¹⁸Using equation (18), the gravity equation (14) can be expressed as follows:

$$\ln \left(\frac{X_{icFt}}{R_{ict}} \right) = \ln \Lambda^1 + \frac{\varepsilon_i}{\sigma-1} \ln(A_{iFt}) + \phi_1 \ln w_{ict} + \phi_1 \psi \frac{k_{ict}}{\bar{w}} + \ln \left[(f_{ict}^E)^{-1} (f_{icFt})^{1-\frac{\varepsilon}{\sigma-1}} \left(\frac{\varphi_{\min,ict}}{\tau_{icFt}} \right)^\varepsilon \right].$$

¹⁹The domestic revenue equation is obtained using expression (18) together with equation (10) when $n = c$ in the summation term:

$$r_{ict}(\varphi) = (\sigma - 1) \ln \left(\frac{\sigma - 1}{\sigma - \beta} \right) + (1 - \sigma) \ln w_{ict} + (\sigma - 1) \ln \varphi_t + \ln A_{ict} + (1 - \sigma) \psi \frac{k_{ict}}{\bar{w}}.$$

least squares would yield inconsistent estimates of ϕ_1 and ϕ_2 . Next, we show how to exploit the structure of the model to obtain instruments for wages.

3.1 Industrial Composition and Wages

The first step is to link the industry-city wage to the industrial composition of the local labor market. In our search and bargaining framework, this link is captured by the worker's outside option. To simplify the exposition, we impose constant exit rates and bargaining power, i.e. $\delta_c = \delta$ and $\beta_i = \beta$. The latter implies that inter-industry wage differentials within local labor markets stem solely from differences in recruitment costs, k_{ic} . Substituting equation (5) in equation (8) yields

$$w_{ic} = \tilde{\gamma}_{1c}\bar{w}_c + \gamma_{2c}k_{ic}, \quad (21)$$

where $\bar{w}_c = \sum_i \eta_{ic}w_{ic}$ is the local average wage and the coefficients $\tilde{\gamma}_{1c} = \frac{\theta_c m_c(\theta_c)}{\rho + \delta + \theta_c m_c(\theta_c)} \in \{0, 1\}$ and $\gamma_{2c} = \left(\frac{\beta}{1-\beta}\right) \left(\frac{\rho+\delta}{1-\delta}\right) \frac{1}{m_c(\theta_c)}$ are both dependent on the tightness of the local labor market. The latter coefficient is increasing in labor market tightness – workers benefit more from hiring costs when firms find it harder to hire. The equation shows that workers in any sector benefit from working in a city with higher wages (quality of jobs) due to the strategic complementarity of wages across industries generated by search frictions and bargaining in the labor market (Beaudry et al., 2012). Since the coefficient $\tilde{\gamma}_{1c}$ is an increasing function of labor market tightness, this benefit depends on the quantity of jobs.

In order to solve equation (21) further, it is useful to decompose the vacancy posting cost, k_{ic} , without loss of generality, as $k_{ic} = \tilde{k}_i + \tilde{k}_c + \tilde{\xi}_{ic}$, where \tilde{k}_i represents a common (across cities) industry component, \tilde{k}_c represents city-specific component, and $\tilde{\xi}_{ic}$ is an idiosyncratic component that sums to zero across industries, within cities. Using this decomposition, solving for \bar{w} and substituting back in equation (21), we obtain:

$$w_{ic} = \gamma_{1c}\tilde{K}_c + (\gamma_{1c} + \gamma_{2c})\tilde{k}_c + \gamma_{1c} \sum_i \eta_{ic}\tilde{\xi}_{ic} + \gamma_{2c}\tilde{k}_i + \gamma_{2c}\tilde{\xi}_{ic}, \quad (22)$$

where $\tilde{K}_c = \sum_i \eta_{ic}\tilde{k}_i$ captures the weighted city-average of national-level vacancy posting costs and $\gamma_{1c} = \frac{\tilde{\gamma}_{1c}\gamma_{2c}}{1-\tilde{\gamma}_{1c}}$. Note that γ_{1c} and γ_{2c} vary by city because of equilibrium differences in the rate at which workers find jobs. It is easy to show that these coefficients can be written as an increasing function of the employment rate, which is a one-to-one function of the tightness of the labor market (Beveridge curve).

To derive an empirical specification in logs, we take a log-linear approximation of equation

(22). In doing so, we explicate the link between industry-city wages, the unobservable tightness θ_c (as captured by γ_{1c} and γ_{2c}) and the observable employment rate, e_c , of the labor market. We choose an expansion point around which the cost of posting vacancies is small. Adding the time subscript, industry-city wages are related to industrial composition in the following way:

$$\ln w_{ict} = \gamma_0 + \frac{\gamma_1}{\gamma_2} K_{ct} + \gamma_2 k_{it} + \gamma_3 k_{ct} + \gamma_4 e_{ct} + \gamma_2 \xi_{ict}, \quad (23)$$

where γ_0 - γ_4 are constant parameters obtained from the linear approximation, $k_{it} = \frac{\tilde{k}_{it}}{\bar{w}}$, $k_{ct} = \frac{\tilde{k}_{ct}}{\bar{w}}$ and $\xi_{ict} = \frac{\tilde{\xi}_{ict}}{\bar{w}}$, where \bar{w} is an arbitrary constant term.²⁰ Equation (23) shows that, at the national level, inter-industry wage differentials are given by $\gamma_2 k_{it}$, which expresses the average wage in industry i relative to an omitted group. Finally, $K_{ct} = \sum_i \eta_{ict} \nu_{it}$, where $\nu_{it} = \gamma_2 k_{it}$ denotes the national industry wage premium. Thus, K_{ct} is a weighted average of industrial wage premia, weighted by industry-city-specific employment shares.

The term K_{ct} plays an essential role in our identification strategy. Since the probability that an unemployed worker finds a job in industry i and city c is proportional to η_{ict} , the term K_{ct} can be thought of as capturing variation in workers' outside option driven by the industrial composition of city c ; i.e., by city c 's specialization pattern across industries that pay intrinsically different wage premia. When the composition of jobs shifts toward higher-paying industries, workers are able to extract more surplus from firms when bargaining through an increase in their threat point. Crucially for the identification strategy, conditional on the employment rate and demand shifter, movements in industrial composition influence trade flows and firm revenues only through their impact on wages. [Beaudry et al. \(2012\)](#) show that outside options are important determinants of industry-city wages in the U.S.. [Tschopp \(2015, 2017\)](#) finds similar results in Germany. Next, we discuss how to exploit variation in K_{ct} to construct model-based instruments for the industry-city wage in equations (19) and (20).

3.2 Instrumental Variables

Our identification strategy exploits variation in K_{ct} and hinges on the following decomposition:

$$\Delta K_{ct} = \sum_i \eta_{ict-1} (\nu_{it} - \nu_{it-1}) + \sum_i \nu_{it} (\eta_{ict} - \eta_{ict-1}).$$

²⁰See Appendix B.2 for details on the linear approximation and specific expressions of γ_0 - γ_4 .

This decomposition is the starting point for our instruments, which, by exploiting the inner structure of the index K_{ct} , are, essentially, Bartik-type instruments, as defined by Goldsmith-Pinkham et al. (2017). The first term captures shifts in national-industrial premia, weighted by the beginning-of-period importance of an industry to the local economy. The second term captures changes in workers' outside options from shifts in the local industrial composition, weighed by the national industrial wage premia.

In order to construct instruments using the decomposition of ΔK_{ct} , we must confront two issues: (1) the national industrial premia, ν_{it} , are not directly observed, and (2) the observed industrial employment shares, η_{ict} , are potentially correlated with the error terms in (19) and (20). We tackle these two issues next.

Estimating National Wage Premia. Equation (23) shows that wages vary because of an industry-specific component (ν_{it}), a city-specific component ($\gamma_0 + \frac{\gamma_1}{\gamma_2} K_{ct} + \gamma_3 k_{ct} + \gamma_4 e_{ct}$) and an idiosyncratic term ($\gamma_2 \xi_{ict}$). An important feature of this equation is that the inclusion of a set of city fixed effects in a wage regression at the industry-city level would allow one to recover national industrial wage premia from the estimated coefficients on industry fixed effects, without directly observing local industrial composition, K_{ct} , and the local component of the vacancy posting cost, k_{ct} .

However, in order to take the model's wage equation to the data, we must confront the fact that workers are heterogeneous in our data but not in the model. Our approach is to treat individuals as representing different bundles of efficiency units of work, where these bundles are treated as perfect substitutes in production. We interpret w_{ict} in (23) as the cost per effective labor unit and index worker characteristics by H_j . Let effective labor units be $\exp(H'_j \beta + a_j)$, where H_j and a_j capture observable and unobservable skills of worker j , respectively. Adding industry, city and time subscripts, workers log wages, $\ln W_{jict}$, are given by:

$$\ln W_{jict} = H'_{jt} b_t + \ln w_{ict} + a_{jict}.$$

This implies that we can estimate national industrial wage premia using the following procedure. First, we estimate, separately by year:

$$\ln W_{jict} = H'_{jt} b_t + D_{ict} + a_{jict}, \tag{24}$$

where D_{ict} are a complete set of city-industry dummies. Variables included in the vector of individual characteristics H'_{jt} are age, the square of age, a gender dummy, a nationality dummy, a categorical variable for education and a full set of education-gender, education-

nationality and education-age interactions. The estimated vector coefficients on the city-industry fixed-effects, D_{ict} , are regression-adjusted city-industry average wages, which we denote by $\ln \widehat{w}_{ict}$.

Then, pooling across years, we estimate an empirical version of (23), regressing $\ln \widehat{w}_{ict}$ on a set of city-year and industry-year fixed effects. The inclusion of the city-year fixed effects absorbs local economic conditions given by $\gamma_0 + \frac{\gamma_1}{\gamma_2} K_{ct} + \gamma_3 k_{ct} + \gamma_4 e_{ct}$ in equation (23) and the coefficients on the industry-year fixed-effects estimate the national-level industrial wage differentials, $\hat{\nu}_{it}$.

Predicting Shares. Since we have many industries within each city-year, we pursue a generalized leave-one-out method that purges a common city component from the national-level industry growth. The procedure that we use closely follows [Greenstone et al. \(2015\)](#). Consider the following equation for local industry-city employment growth:

$$\Delta \ln L_{ict} = g_{it} + g_{ct} + \tilde{g}_{ict}, \quad (25)$$

where g_{ct} are city-time fixed effects and g_{it} are industry-year effects. This equation describes local industry employment growth as stemming from national-level factors common across cities (g_{it}), city-level factors that are common across industries (g_{ct}), and an idiosyncratic city-industry factor (\tilde{g}_{ict}). The inclusion of g_{ct} is meant to absorb growth due to conditions in the local economy, such as demand shocks. The vector of coefficients on the g_{it} fixed-effects are associated with national-level forces. We use their estimates, denoted \hat{g}_{it} , to predict local industry size based on local base-period employment:

$$\hat{L}_{ict} = L_{ic0} \prod_{s=1}^t (1 + \hat{g}_{is}),$$

for $t \geq 1$, where L_{ic0} is a base-period level of employment in industry i in the local economy c . We then convert predicted employment into shares as follows:

$$\hat{\eta}_{ict} = \frac{\hat{L}_{ict}}{\sum_j \hat{L}_{jct}}.$$

Constructing Instruments. With $\hat{\eta}_{ict}$ and $\hat{\nu}_{it}$ at hand, we construct

$$IVW_{ct} = \sum_i \hat{\eta}_{ict-1} \Delta \hat{\nu}_{it},$$

$$IVB_{ct} = \sum_i \hat{\nu}_{it} \Delta \hat{\eta}_{ict},$$

where $\hat{\eta}_{ict}$ are only functions of base period shares and national growth rates. Variation in both IVW_{ct} (the ‘within instrument’) and IVB_{ct} (the ‘between instrument’) across cities comes from differences in initial local industrial composition. Thus, identification comes from within-industry, cross-city comparisons.

For our instruments to be valid, we require shocks to the industry-city-specific residual component in vacancy posting, fixed, entry and trade costs (as captured by the error terms in the gravity and revenue equations) to be independent from base-period local industrial employment composition. We also require that general city-specific improvements are independent of past relative employment for base-period η s.

The literature has recently turned to data-driven tests to assess the plausibility of the validity of base-period industrial structure. Following [Goldsmith-Pinkham et al. \(2017\)](#), who provide a detailed treatment of Bartik instruments and the conditions under which they are valid, we assess (i) the relevance of our instruments and (ii) the correlation of our instruments with observables in the base-year. We perform and discuss each of these tests in Section 5.

As an alternative to IVW_{ct} and IVB_{ct} , we also construct instruments based on the non-manufacturing sector only. That is, we construct industrial shares within the non-manufacturing sector so the shares across industries within the non-manufacturing sector of a city sums to one. The conditions under which these alternative instruments are valid are identical to those of our baseline instruments, and alleviate any concerns that the correlation between our instruments and manufacturing wages is mechanical by exploiting variation in our instruments that originates outside the tradable sectors.

4 Data

This study uses two different data sources: the weakly anonymous Sample of Integrated Labour Market Biographies (SIAB) [Years 1975 - 2010] and the Linked-Employer-Employee Data (LIAB) [cross-sectional model 2 1993-2010 (LIAB QM2 9310)] from the Institute of Employment Research (IAB). Data access was on-site at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the University of Michigan, the Cornell

Institute for Social and Economic Research and subsequently via remote data access.²¹

SIAB Data. The SIAB data is a 2% random sample of individual accounts drawn from the Integrated Employment Biographies (IEB) data file assembled by the IAB. These data cover all employees registered by the German social insurance system and subject to social security. Civil servants and self-employed workers are not covered. The SIAB provide spell-data information on individual characteristics as such as gender, year of birth, nationality or education, and document a worker’s entire employment history, e.g. an individual’s employment status, full- or part-time status, occupational status, occupation and daily wage. Hours of work are not included in the IEB. Earnings exceeding the contribution assessment ceiling for social insurance are only reported up to this limit.²² Administrative individual data are supplemented with workplace basic information taken from the Establishment History Panel (BHP). Establishment variables are measured on June 30 of each year and include information on location, industry, year of first and last appearance of the establishment, total number of employees, number of full employees, number of part-time employees and median wage of the establishment. Establishment and individual data are merged using employment spells which cover June 30.

LIAB Data. The LIAB data matches the IAB Establishment Panel data with individual social security data from the IAB on June 30 and comprises data from a representative annual establishment survey, stratified according to establishment size, industry and federal state. The survey provides information on establishment-level exports, employment and other performance-related measures, such as sales. For consistency with theory, we refer to these establishments as firms in the empirical analysis.

Cities and Industries. We define cities according to [Kropp & Schwengler \(2011\)](#) definition of labor markets. There are 24 cities; 19 in West Germany and 5 in East Germany.²³ There are 58 industries (“Abteilungen”), of which 29 belong to the manufacturing sector, grouped according to the 1993 time-consistent 3-digit classification of economic activities. In compliance with the FDZ guidelines, each industry-city cell includes at least 20 workers’ observations.²⁴

²¹See [Heining et al. \(2013\)](#), [Fischer et al. \(2009\)](#) and [Heining et al. \(2014\)](#) for further data documentation.

²²We drop top coded observations.

²³[Kropp & Schwengler \(2011\)](#) correspondence table between districts, labor markets and regions can be downloaded at <http://www.iab.de/389/section.aspx/Publikation/k110222301>.

²⁴Table 7 in the Appendix provides summary statistics of export values, revenue and employment at the firm level. Table 8 in the Appendix shows statistics of variables at the industry-city level.

Construction of the Main Variables. We use the LIAB data to construct industry-city-specific export shares in revenues and firm-level domestic revenues. We first compute firm-level export values using sales and the share of exports in sales, which are both available at the firm level in the LIAB data. Firm-level domestic revenues are obtained by subtracting exports from sales. The industry-city export shares are obtained by aggregating firm revenues and exports by industry-city-year, weighting each observation using the weights provided in the establishment survey.

The SIAB data are used to construct industry-city wages, national industrial wage premia, local industrial employment shares and instruments, which are then merged to the LIAB data by the Institute of Employment research. Each of these measures are constructed following the procedure described in Section 3.2. To estimate log industry-city wages from the wage regression at the worker level we first transform wages into real wages using the consumer price index, base 2005, provided by the German federal statistical office. Among the variables included in the vector of individual characteristics, our educational variable includes the following categories: without vocational training, apprenticeship, high school with *Abitur*, high school without *Abitur*, polytechnic, university. The nationality variable is restricted to two categories; German nationals and foreigners. In the second step which estimates the national industrial wage premia, we weigh observations by the size of the city-industry in the base-period so that the influence of each observation is proportional to its importance in that year.

Finally, to predict local industry size, we average industry-city employment over the period 1992-1993, i.e. $L_{ic0} = (L_{ic1992} + L_{ic1993})/2$. We then leave one year out and first predict employment, \hat{L}_{ict} , in 1995, which restricts our sample to the period 1996-2010 since IVB_{ct} and IVW_{ct} both use $t - 1$ predicted employment shares.

5 Results

Instruments Relevance and Validity. We start by checking the relevance of our instruments. We perform two tests. The first is an analysis of variance (ANOVA) of the regressions used to construct industrial national-wage premia and employment growth. For our instruments to be relevant, we require the national-component ν_{it} in (23) to be a significant determinant of wages. Similarly, we require the national-growth rate component g_{it} in (25) to be a strong predictor of local industry growth.

Results from the ANOVA test are shown in Table 1. The first and second columns regress $\Delta \ln L_{ict}$ and $\ln w_{ict}$ on an entire set of city-year and industry-year fixed effects, respectively. The results show that national-level components explain a considerable part of the variation

in industry-city adjusted wages and employment growth.

Table 1: ANOVA of industry-city growth rates and adjusted wages

Dependent variable	$\Delta \ln L_{ict}$	$\ln w_{ict}$
Model SS	94.21	804.76
Industry-year FE SS	49.01	509.30
City-year FE SS	12.74	268.19
Residual	115.26	79.22
Observations	16884	17822
R-squared	0.450	0.91

The second relevance test we conduct is the standard first-stage F -test. This is a direct test of the main mechanism of wage determination in our model; that is, it tests that our proxies for outside options in a city matter for industry-city wage growth. Table 2 shows the first-stages of regressing log industry-city (adjusted) wages on our instruments and an entire set of industry-time dummies, clustering standard errors at the city level. Both regressions are weighted using the number of establishments in an industry-city cell at $(t-1)$. The first column shows the first-stage using the baseline instruments, and column 2 presents the estimates obtained with the non-manufacturing counterpart of IVW_{ct} and IVB_{ct} . The F -statistics on the baseline instruments is 34 and close to 73 when focusing on the non-manufacturing sector only, therefore suggesting that changes in workers' outside options, stemming from shifts in industrial composition, matter for wages. In both columns, only the coefficient on IVW_{ct} is statistically significant at the 1% level. This indicates that most of the yearly variation in outside options and wages at the city level come from shifts in national-level industrial premia rather than in industrial employment.

As discussed in [Goldsmith-Pinkham et al. \(2017\)](#), the exclusion restriction necessary for Bartik-type instruments to be valid is based on the exogeneity of the base-period industrial structure. To test for the validity of our instruments, we report the standard Hansen's J over-identification test in all of our 2SLS estimations below. Note that we have over-identifying restrictions because the decomposition of the index ΔK_{ct} produces two instruments: the between and the within instruments discussed above. This test essentially asks whether each instrument, individually, would produce the same second-stage estimate. Intuitively, each of our instruments are functions of base-period industrial structure, but are weighted differently by different types of national-level shocks. If the industrial structure is correlated with the

error term, we would expect each instrument would weigh this correlation differently and the second-stage estimates to diverge. As we show below, we find no evidence that this is the case. However, one should note, the low predictive power of the between instrument in the first-stage might compromise the power of this test.

Table 2: First stages

	$\Delta \ln w_{ict}$	
IVB _{ct}	1.049	
($\sum_i \hat{\nu}_{it} \Delta \hat{\eta}_{ict}$)	(1.081)	
IVW _{ct}	2.497***	
($\sum_i \hat{\eta}_{ict-1} \Delta \hat{\nu}_{it}$)	(0.415)	
IVB _{ct} , non-manuf.	1.657	
($\sum_i \hat{\nu}_{it} \Delta \hat{\eta}_{ict}$)	(1.078)	
IVW _{ct} , non-manuf.	4.826***	
($\sum_i \hat{\eta}_{ict-1} \Delta \hat{\nu}_{it}$)	(0.441)	
Industry-year FE	yes	yes
Observations	3713	3713
F-statistics	34.05	72.84

Notes: Both regressions are weighted using the number of establishments in an industry-city cell at (t-1). Standard errors, in parentheses, are clustered at the city level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level.

Second Stages. Table 3 shows our estimates of the gravity equation (19). Recall that the wage elasticity has a structural interpretation; e.g. equal to $-\frac{\kappa\sigma}{(\sigma-1)}$ under MC-FE-HET. The first column of Table 3 shows the OLS estimates of the gravity equation. As discussed above, wages are mechanically endogenous in this equation and under no circumstances we expect to recover consistent estimates of the parameter of interest; we present them only for completeness. Thus, we turn our attention to columns 2-5 which contain the second-stage results of the gravity equation when we instrument for wages.

In column 2 of Table 3, we use the baseline instrument set of IVW_{ct} and IVB_{ct} . The estimated wage elasticity is -6.46, significant at the 5 percent level. In columns 3-5, we assess

the robustness of this estimate to using the non-manufacturing based versions of IVW_{ct} and IVB_{ct} (column 3), to including city-specific linear trends (column 4) and to including city-specific linear trends along with the non-manufacturing instruments (column 5). The estimates are statistically significant and fairly stable across specifications. In column 5, the most demanding specification, we obtain an estimate of about -7.5. In the panel at the bottom of the table, we report the p -value of the Hansen’s J test. In each specification, we cannot reject the null that our instruments are valid.

It is useful to interpret these results through the lens of our model. Our 2SLS estimates of the gravity equation instrument changes in city-industry wages with measures of the change in the value of workers’ outside options. These outside options depend on predicted shifts in the industrial structure (IVB_{ct}) and shifts in the national-level industry premia (IVW_{ct}). Identification comes from within-industry, across city variation in predicted wages. Improvements in workers’ outside options lead to higher bargained wages and, thus, higher unit costs faced by producers. Conditional on foreign demand, export shares in industry i in city c fall. The magnitude of this effect is governed by the wage elasticity, and our estimates suggest that a one percent increase in labour costs reduces export shares by about 7 percent.

Finally, we turn to the estimation of the elasticity of substitution in consumption, σ , in the domestic revenue equation (20). Table 4 has a similar layout as Table 3. Note that, in each specification, we include firm fixed effects along with industry-by-year fixed effects. In columns 4 and 5, we add linear city trends. The bottom panel of the table contains the first-stage results. The Angrist-Pischke p -value indicate that our instruments are strong predictors of wages. The first row of Table 4 presents the estimates of σ . The latter are remarkably stable around 1.2 across various specifications. This result suggests that substitutability among varieties in demand is low, which is not surprising given the relatively high level of industrial aggregation in our data.

Our estimate is somewhat smaller than the estimates reported in the literature. For instance, [Broda & Weinstein \(2006\)](#) report a median elasticity of substitution of 2.2 over the period 1990-2001 for SITC-3 industries. More recently, [Soderbery \(2015\)](#) estimates a median elasticity of substitution of 1.855 across HS8 products. Methodological differences aside, our dataset features a much coarser industry classification than [Soderbery \(2015\)](#), which could partially explain this gap. Combining the estimate of -7.5 in the gravity equation and σ , we obtain a trade elasticity of $\kappa = 1.25$ under MC-FE-HET and of 6.5 under alternative market structures. Thus, our trade elasticity falls comfortably in the range of estimates documented in the literature (see Table 3.5 of [Head et al. \(2014\)](#)).

In Section C.2 of the Appendix, we investigate additional robustness exercises to probe the validity of our Bartik-type instruments by performing several specification checks suggested

Table 3: Gravity estimation

Dependent variable	$\Delta \ln \left(\frac{X_{ict} F_t}{R_{ict}} \right)$				
	OLS	IV baseline	IV non-manuf.	IV baseline	IV non-manuf.
$\Delta \ln w_{ict}$	-2.010 (1.387)	-6.459** (2.507)	-7.349*** (2.094)	-5.439** (2.474)	-7.465*** (2.250)
Industry-year FE	yes	yes	yes	yes	yes
City FE	yes	yes	yes	no	no
City linear trend	no	no	no	yes	yes
Observations	3713	3713	3713	3713	3713
Hansen		0.746	0.323	0.835	0.578
F-statistics		34.05	72.84	36.96	73.27
AP p-value		0.00	0.00	0.00	0.00

Notes: Both regressions are weighted using the number of establishments in an industry-city cell at (t-1). Standard errors, in parentheses, are clustered at the city level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level.

by [Goldsmith-Pinkham et al. \(2017\)](#). First, we assess the correlation between our instruments and characteristics of cities in the base year. We then investigate the relationship between these variables and the base-period industrial structure. The idea is that if the instruments (through initial industry shares) are correlated with city characteristics in the base year, then any trend or shock that is correlated to those city characteristics could also be correlated with the instruments, therefore potentially violating the exclusion restriction we require for our instruments to be valid. Since we cannot rule out that initial industrial structure is correlated with city-level labour market characteristics, we assess the robustness of our main specification to including additional city-level, base-year control (local, share of college graduates, females, share of Germans and local log employment rate and workforce) in the specifications of the gravity and revenue equations. We find that our main coefficient estimates are remarkably robust to the inclusion of these additional controls.

Table 4: Revenue estimation

Dependent variable	$\Delta \ln r_{ict}(\varphi)$				
	OLS	IV baseline	IV non-manufacturing	IV baseline	IV non-manufacturing
Elasticity of substitution in consumption (σ)	1.418*** (0.301)	1.186** (0.476)	1.209*** (0.412)	1.224** (0.481)	1.231*** (0.410)
Industry-year FE	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes
City linear trend	no	no	no	yes	yes
Observations	49711	49711	49711	49711	49711
Hansen		0.500	0.787	0.507	0.821
F-statistics		14.73	28.58	14.70	28.45
AP p-value		0.00	0.00	0.00	0.00

Notes: All columns are weighted using establishment weights. Standard errors, in parentheses, are clustered at the city level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level.

6 Application: The Fall of the Iron Curtain

Our relatively small estimate of the elasticity of substitution in consumption suggests that omitting unemployment and firm heterogeneity might lead to an underestimation of the welfare gains from trade. We examine this possibility in this section. As in [Redding & Sturm \(2008\)](#), we exploit the reunification of East and West Germany in 1990 as a natural experiment to study the welfare consequences of increased market access across cities of West Germany.

We take the trade elasticity, changes in local employment rates, domestic trade shares and industry composition as given by the data and ask: how do the welfare gains from trade between 1989 and 1991 differ relative to those predicted by ACR’s welfare formula when changes in unemployment are accounted for? The answer to this question, summarized in table 5, depends on the product market structure and on firm heterogeneity.

The relative gains from trade under MC-FE-HET, given in column 1 of Table 5, depend on the elasticity of substitution in consumption. We set $\hat{\sigma} = 1.2$ from Table 4. To be clear, this counterfactual exercise is in the spirit of ACR; that is, the relative gains formula $\dot{e}_c^{1+\frac{1}{\sigma-1}}$

Table 5: Gains from trade in frictional settings relative to those predicted by ACR’s welfare formula

MC-FE-HET (Melitz (2003) and Chaney (2008))	MC-FE-HOM (Krugman (1980))	PC or MC-RE (Armington (1969))
$\dot{e}_c^{1+\frac{1}{\sigma-1}}$ $\hat{\sigma} = 1.2$	$\dot{e}_c^{1+\frac{1}{\hat{\varepsilon}}}$ $\hat{\varepsilon} = 6.5$	\dot{e}_c

assumes that two MC-FE-HET models, one featuring search frictions and unemployment (our model) and the other featuring frictionless labor markets (ACR), are calibrated to deliver the same trade elasticity and changes in local employment rates, domestic trade shares and industry composition.

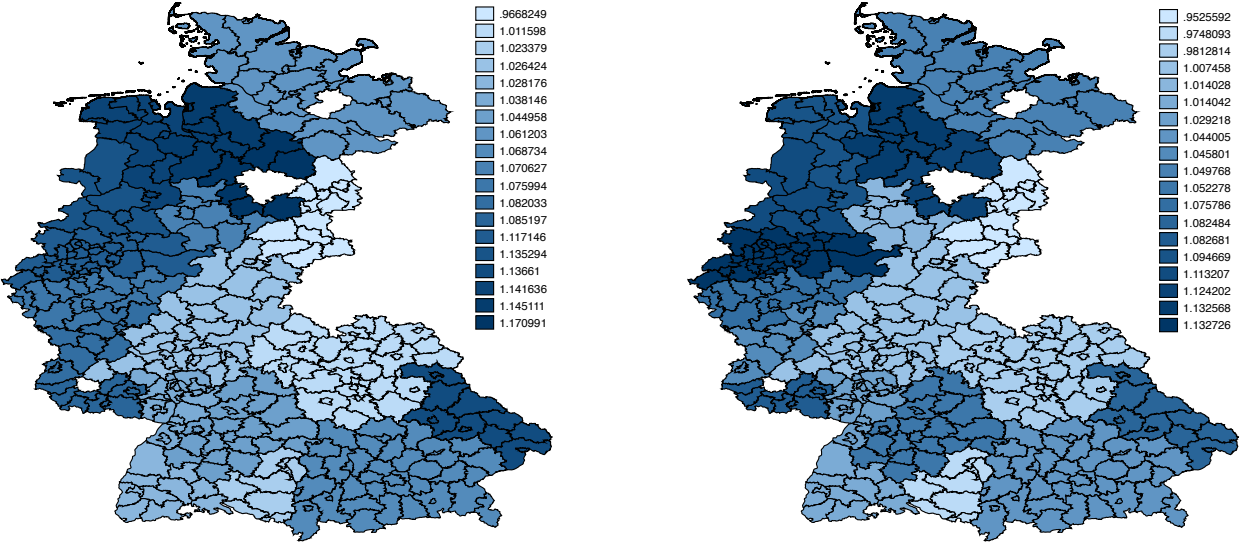
The same principle applies when comparing the relative gains from trade under alternative market structures. In column 2 of Table 5, the relative gains from trade under MC-FE-HOM are a function of the trade elasticity. Following the usual practice in the literature, we recover it from the gravity equation. Under MC-FE-HOM, the trade elasticity is equal to the wage elasticity minus one. Based on our estimates from Table 4, we set $\hat{\varepsilon} = 6.5$. Finally, the last column of the table shows that, under PC or MC-RE, the relative gains from trade solely depend on how market access affects the unemployment rate across local labor markets.

For each column, we compute the relative gains from trade, using both observed and counterfactual local employment rate growth of West German cities between 1989 and 1991. Counterfactual employment rate growth purges observed growth from city-specific pre-1989 trends. Specifically, we construct city-specific yearly average growth rates between 1985 and 1989 and use them to predict the employment rates that would have prevailed in 1991 if city employment rates had grown at their pre-1990 trend. We then construct employment rate growth rates attributable to the fall of the Iron Curtain as deviations from the counterfactual rates. Table 6 presents summary statistics with observed and counterfactual employment rate growth rates.

For the median local labor market in West Germany, we find that our formula under MC-FE-HET yields welfare gains that are 7.1% greater than those predicted by ACR’s formula. In contrast, accounting for changes in the employment rate in frameworks with homogeneous firms, monopolistic competition with restricted entry or perfect competition yield relative welfare gains that are between 0.8% and 1.3% larger for the median labor market. Results corresponding to the MC-FE-HET case are mapped in Figure 1.²⁵

²⁵Results for the cases for the cases MC-FE-HOM, MC-RE and PC are mapped in Figures 2 and 3 of the Appendix.

Figure 1: Fall of the Iron Curtain: welfare gains from trade accounting for unemployment changes relative to ACR, under MC-FE-HET (West Germany).



Notes: The left panel is constructed using observed employment rate growth between 1989 and 1991. The right panel is based on employment rate growth, purged from pre-1990 city trends. Both panels use $\hat{\sigma} = 1.2$.

Table 6: Fall of the Iron Curtain: gains from trade in a framework with unemployment relative to its frictionless counterpart, across local labor markets in West Germany

Model Setup	Mean	Std. Dev.	Min.	Max.	P25	P50	P75
MC-FE-HET:							
Observed growth ($\dot{e}_c^{1+\frac{1}{\sigma-1}}$)	1.075	0.054	0.967	1.171	1.028	1.071	1.135
Counterfactual growth ($\hat{e}_c^{1+\frac{1}{\sigma-1}}$)	1.053	0.054	0.953	1.133	1.014	1.050	1.095
MC-FE-HOM:							
Observed growth ($\dot{e}_c^{1+\frac{1}{\varepsilon}}$)	1.014	0.010	0.994	1.031	1.005	1.013	1.025
Counterfactual growth ($\hat{e}_c^{1+\frac{1}{\varepsilon}}$)	1.010	0.010	0.991	1.024	1.003	1.009	1.018
PC or MC-RE:							
Observed growth (\dot{e}_c)	1.012	0.009	0.994	1.027	1.005	1.011	1.021
Counterfactual growth (\hat{e}_c)	1.008	0.009	0.992	1.021	1.002	1.008	1.015

Notes: MC-FE-HET indicates monopolistic competition with free entry and heterogeneous firms. MC-FE-HOM indicates monopolistic competition with free entry and homogeneous firms. PC indicates perfect competition. MC-RE indicates monopolistic competition with restricted entry. ‘Observed growth’ is constructed using the observed employment rate growth between 1989 and 1991. ‘Counterfactual growth’ is constructed using the employment rate growth over the same period, net of the pre-1990 city trend. The number of observations in each column is 19.

Figure 1 exhibits substantial variation in the welfare gains from trade across local labor markets; e.g. ranging from 0.95 to 1.13 when using counterfactual employment growth rates. Interestingly, Figure 1 suggests that in a framework with heterogeneous firms, omitting labor market frictions might lead to underestimate the welfare gains from market access to up to 13% (up to 17% when focusing on *observed* employment rate growth rates), with the bias being the largest close to the border of neighboring countries on the West side. The map also suggests that ACR’s welfare formula may overestimate the gains by around 5% in a few cities close to the East-West German border on the East side of the map.

7 Conclusion

We develop a model and an empirical strategy to estimate the gains from trade in the presence of frictions in the labor market. Our model delivers a welfare formula showing that trade liberalization affects welfare through two channels: (i) the traditional adjustment margin studied in ACR, which depends on the trade elasticity and on changes in the share of domestic expenditure; and (ii) a new adjustment margin operating through shifts in the employment rate. A key takeaway from the theory is that the micro details of the model

matter when evaluating the gains from trade in economies with equilibrium unemployment. In particular, conditional on the share of domestic expenditure and the trade elasticity, the welfare implications of trade-induced changes in unemployment depend on the goods market structure and on the existence of firm heterogeneity.

The paper proposes a novel identification strategy to uncover the two key structural parameters needed to analyze welfare changes in a broad range of market structures, the trade elasticity and the elasticity of substitution in consumption. Our identification strategy follows naturally from our model, based on Bartik-style instruments that exploit exogenous differences in industrial employment composition across local labor markets. Applying this methodology to study the fall of the Iron Curtain, we find that omitting trade-induced changes in the employment rate typically leads to an underestimation of the gains from trade in West German local labor markets. This bias is particularly important when the underlying market structure is monopolistic competition with free entry and heterogeneous firms.

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Appendix (incomplete)

A Theoretical Framework

This section contains details of the model and of derivations that were omitted in the main text. The presentation is not necessarily self-contained but rather complementary with Section 2 of the paper.

The demand structure, introduced in subsection XXX, is common to all the market structures considered in the paper. Subsections XXX to XXX focus on the case of monopolistic competition with free entry and heterogeneous firms (MC-FE-HET). Subsections XXX and XXX consider the special cases of homogeneous firms (MC-FE-HOM) and restricted entry (MC-RE-HET), respectively. Finally, subsection XXX analyzes a perfectly competitive multi-industry Armington model with frictional labor markets (PC).

A.1 Demand

The preferences of the normative representative consumer in location n are described by a time-separable and stationary two-tier utility function

$$U_n = \sum_{t=1}^{\infty} \left(\frac{1}{1+\rho} \right)^t \prod_{i=1}^I (Y_{int})^{\alpha_i}, \quad \sum_{i=1}^I \alpha_i = 1, \quad (26)$$

where the consumption of good i in period t is a CES aggregate

$$Y_{int} = \left[\int_{\omega \in \Omega_{int}} q_{int}(\omega)^{\frac{\sigma_i-1}{\sigma_i}} d\omega \right]^{\frac{\sigma_i}{\sigma_i-1}}, \quad \sigma_i > 1.$$

$q_{int}(\omega)$ denotes the consumption of variety ω of good i and Ω_{int} is the set of varieties available to the consumer. The latter is endogenous under MC-FE-HET and MC-FE-HOM, and exogenous under PC and MC-RE. The price index dual to Y_{int} is

$$P_{int} = \left[\int_{\omega \in \Omega_{int}} p_{int}(\omega)^{1-\sigma_i} d\omega \right]^{\frac{1}{1-\sigma_i}},$$

where $p_{int}(\omega)$ denotes the price of variety ω .

In each location, there is a sequence of markets in one-period-ahead claims to consumption of each good i . We assume that these assets are not tradable across locations. Let a_{int+1} denote the claims to time $t+1$ consumption of good i and Q_{int} denote the price of 1 unit of this asset at time t . Note that both quantity and price of this asset are state-independent

in the absence of aggregate uncertainty, a property that holds in equilibrium. The consumer then faces a sequence of budget constraints

$$\sum_i P_{int} Y_{int} + a_{int+1} Q_{int} \leq \sum_i a_{int} P_{int} + W_{nt}, \quad t \geq 1,$$

where W_{nt} denotes aggregate income (labor income and aggregate profits, if any) in location n . We rule out Ponzi schemes by implicitly imposing a natural debt limit.

The first-order conditions with respect to Y_{mnt} for good $m \in \{1, \dots, I\}$, and the Langrange multiplier η_{nt} for the time t budget constraint, can be expressed as

$$\alpha_m \left(\frac{1}{1 + \rho} \right)^t \prod_{i=1}^I (Y_{int})^{\alpha_i} (Y_{mnt})^{-1} = \eta_{nt} P_{mnt}, \quad (27)$$

$$\sum_i P_{int} Y_{int} + a_{int+1} Q_{int} = \sum_i a_{int} P_{int} + W_{nt}. \quad (28)$$

In a stationary equilibrium, $a_{int+1} = 0$ for all i and t , and $W_{nt} = W_n$ for all t . Imposing these conditions in (28) and using (27) yields

$$\sum_{m=1}^I \alpha_m \left(\frac{1}{1 + \rho} \right)^t \prod_{i=1}^I (Y_{int})^{\alpha_i} (\eta_{nt})^{-1} = W_n. \quad (29)$$

Let $\tilde{V}_{nt} = \prod_{i=1}^I (Y_{int})^{\alpha_i}$. Under stationarity, $\tilde{V}_{nt} = \tilde{V}_n$ and $Y_{mnt} = Y_{mn}$ for all t . Equation (29) then becomes

$$\left(\frac{1}{1 + \rho} \right)^t = \frac{W_n}{\tilde{V}_n} \eta_{nt}. \quad (30)$$

Plugging (30) into (27) with $Y_{mnt} = Y_{mn}$ for all t , we obtain

$$\tilde{V}_n = \prod_{i=1}^I (\alpha_i)^{\alpha_i} \frac{W_n}{\prod_{i=1}^I (P_{in})^{\alpha_i}}. \quad (31)$$

In turn, plugging (31) into (26) yields V_n , the indirect utility function in the stationary equilibrium,

$$V_n = (\rho)^{-1} \prod_{i=1}^I (\alpha_i)^{\alpha_i} \frac{W_n}{\prod_{i=1}^I (P_{in})^{\alpha_i}}. \quad (32)$$

A.2 The Firm's Problem

Throughout this section, we consider a firm with productivity φ in industry i located in city c .

A.2.1 The (Conditional) Revenue Function

Suppose that the firm is employing l production workers and serving a given set of destinations at some point in time. Let $I_{icn}(\varphi)$ denote an export decision indicator for an arbitrary destination n . In this section, we take l and $I_{icn}(\varphi)$ as given and characterize the optimal allocation of workers across destinations served by the firm. This will allow us to derive the firm's revenue function conditional on l and $I_{icn}(\varphi)$.

Let $l_{icn}(\varphi)$ denote the mass of production workers allocated by the firm to serve market n . Then $l = \sum_n I_{icn}(\varphi)l_{icn}(\varphi)$. At a given point in time, the firm's revenue, output and demand in any destination n can be written, respectively, as

$$r_{icn}(\varphi) \equiv p_{icn}(\varphi)q_{icn}(\varphi), \quad (33)$$

$$y_{icn}(\varphi) = l_{icn}(\varphi)\varphi, \quad (34)$$

$$q_{icn}(\varphi) = X_{in} \frac{(p_{icn}(\varphi))^{-\sigma_i}}{(P_{in})^{1-\sigma_i}}, \quad (35)$$

where $l_{icn}(\varphi)$ is the mass of production workers hired by the firm to serve market n .²⁶ Moreover, due to transportation costs,

$$q_{icn}(\varphi) = y_{icn}(\varphi)(\tau_{icn})^{-1}. \quad (36)$$

Using (34), (35) and (36)

$$q_{icn}(\varphi) = l_{icn}(\varphi)\varphi(\tau_{icn})^{-1}, \quad (37)$$

$$p_{icn}(\varphi) = \left(\frac{l_{icn}(\varphi)\varphi}{\tau_{icn}A_{in}} \right)^{\frac{1}{\sigma_i}}, \quad (38)$$

²⁶Note that these expressions apply at any given point in time t , not just in stationary equilibrium. Because in this section we focus on a static problem, however, we simplify notation by omitting the time index.

where $A_{in} = X_{in} (P_{in})^{\sigma_i - 1}$ is the industry-specific demand shifter in destination n .

Equations (37) and (38), imply that revenue from sales in n can be written as a function of $l_{icn}(\varphi)$,

$$r_{icn}(\varphi) = (A_{in})^{\frac{1}{\sigma_i}} \left(\frac{l_{icn}(\varphi)\varphi}{\tau_{icn}A_{icn}} \right)^{\frac{\sigma_i - 1}{\sigma_i}}. \quad (39)$$

Using (38), we can then express the marginal revenue of allocating an additional production worker to serve market n as

$$\frac{\partial r_{icn}(\varphi)}{\partial l_{icn}(\varphi)} = p_{icn}(\varphi) \left(\frac{\varphi}{\tau_{icn}} \right) \left(\frac{\sigma_i - 1}{\sigma_i} \right).$$

An efficient allocation of workers requires equating marginal revenue across all destinations. This implies

$$p_{icn}(\varphi) = \tau_{icn} p_{icc}(\varphi), \quad (40)$$

for all n . Using (38) and (40), relative employment across any two destinations n and n' served by the firm can be written as

$$\frac{l_{icn}(\varphi)}{l_{icn'}(\varphi)} = \frac{A_{icn}}{A_{icn'}} \left(\frac{\tau_{icn}}{\tau_{icn'}} \right)^{1 - \sigma_i}.$$

For $n' = c$, $\tau_{icc} = 1$ implies

$$l_{icn}(\varphi) = l_{icc}(\varphi) (\tau_{icn})^{1 - \sigma_i} \left(\frac{A_{in}}{A_{ic}} \right). \quad (41)$$

Using $l = \sum_n I_{icn}(\varphi) l_{icn}(\varphi)$,

$$l_{icc}(\varphi) = \frac{A_{ic}}{\sum_{n'} I_{icn'}(\varphi) A_{in'} (\tau_{icn'})^{1 - \sigma_i}} l. \quad (42)$$

Moreover, substituting (42) into (41) yields

$$l_{icn}(\varphi) = \frac{(\tau_{icn})^{1 - \sigma_i} A_{in}}{\sum_{n'} I_{icn'}(\varphi) A_{in'} (\tau_{icn'})^{1 - \sigma_i}} l. \quad (43)$$

The firm's total revenue conditional on l is $r_{ic}(l; \varphi) = \sum_n r_{icn}(\varphi) I_{icn}(\varphi)$. Using (39) and

(43), we can express it as

$$r_{ic}(l; \varphi) = \left[\sum_n I_{icn}(\varphi) A_{in} (\tau_{icn})^{1-\sigma_i} \right]^{\frac{1}{\sigma_i}} (l\varphi)^{\frac{\sigma_i-1}{\sigma_i}}. \quad (44)$$

A.2.2 Optimal Vacancy Posting

We now study the dynamic behavior of the firm, taking all export decisions as given and constant over time. In a stationary equilibrium, the firm faces a time-invariant revenue function given by (44). The firm determines its optimal employment growth by posting vacancies, denoted v , with the goal of maximizing the present value of expected profits. We show that employment in a firm that starts with no workers reaches its optimal long-run level in the following period.

Suppose that the firm is currently employing l production workers. Then it solves

$$\Pi_{ic}(l; \varphi) = \max_v \frac{1}{1+\rho} \left\{ r_{ic}(l; \varphi) - w_{ic}(l; \varphi)l - w_{ic} \sum_n I_{icn}(\varphi) f_{icn} - k_{ic}v + (1 - \delta_c) \Pi_{ic}(l'; \varphi) \right\},$$

s.t. $l' = l + m_c(\theta_c)v$,

where l' is the level of employment next period. The first order condition for vacancy posting can be written as:

$$(1 - \delta_c) \frac{\partial \Pi_{ic}(l'; \varphi)}{\partial l'} = \frac{k_{ic}}{m_c(\theta_c)}, \quad (45)$$

Note that optimal employment size is independent of current employment l and constant over time as long as the firm is not forced to exit the market. Hence the firm converges to its optimal employment size in one period. From this point on, $l = l'$. Using this condition and the envelope theorem yields

$$\frac{\partial \Pi_{ic}(l; \varphi)}{\partial l} = \frac{1}{\rho + \delta_c} \left[\frac{\partial r_{ic}(l; \varphi)}{\partial l} - w_{ic} - \frac{\partial w_{ic}(l; \varphi)}{\partial l} l \right]. \quad (46)$$

Combining (45) and (46) with $l = l'$, we can obtain the implicit optimal pricing rule of the firm,

$$\frac{\partial r_{ic}(l; \varphi)}{\partial l} = \frac{\partial w_{ic}(l; \varphi)}{\partial l} l + w_{ic} + \frac{k_{ic}}{m_c(\theta_c)} \left(\frac{\rho + \delta_c}{1 - \delta_c} \right). \quad (47)$$

A.2.3 Bargaining

This section follows the analysis in [Felbermayr et al. \(2011\)](#). As in [Stole & Zwiebel \(1996\)](#), we assume that the bargaining outcome over the division of the total surplus from a match satisfies the following surplus-splitting rule:

$$(1 - \beta_i) [E_{ic}(l; \varphi) - U_c] = \beta_i \frac{\partial \Pi_{ic}(l; \varphi)}{\partial l}, \quad (48)$$

where U_c is the worker's outside option (i.e. the value of unemployment) and $E_{ic}(l; \varphi)$ is the value of employment in a firm with productivity φ and l production workers. The Bellman equation for workers can be written as:

$$[E_{ic}(l; \varphi) - U_c] = \frac{w_{ic}(l; \varphi) - \rho U_c}{(\rho + \delta_c)}. \quad (49)$$

Inserting (46) and (49) into (48) yields

$$w_{ic}(l; \varphi) = (1 - \beta_i) \rho U_c + \beta_i \frac{\partial r_{ic}(l; \varphi)}{\partial l} - \beta_i \frac{\partial w_{ic}(l; \varphi)}{\partial l} l. \quad (50)$$

Using the revenue function (44), one can verify by direct substitution that

$$w_{ic}(l; \varphi) = (1 - \beta_i) \rho U_c + \left(\frac{\sigma_i}{\sigma_i - \beta_i} \right) \frac{\partial r_{ic}(l; \varphi)}{\partial l} \beta_i, \quad (51)$$

solves (50). Differentiating this equation with respect to l , we obtain:

$$\frac{\partial w_{ic}(l; \varphi)}{\partial l} = \left(-\frac{\beta_i}{\sigma_i - \beta_i} \right) \frac{\partial r_{ic}(l; \varphi)}{\partial l} \frac{1}{l}.$$

Substituting this expression in (47) yields

$$w_{ic}(l; \varphi) = \left(\frac{\sigma_i}{\sigma_i - \beta_i} \right) \frac{\partial r_{ic}(l; \varphi)}{\partial l} - \frac{k_{ic}}{m_c(\theta_c)} \left(\frac{\rho + \delta_c}{1 - \delta_c} \right). \quad (52)$$

Together (51) and (52), one can express the Wage Curve as a function of θ :

$$w_{ic} = \rho U_c + \frac{\beta_i}{(1 - \beta_i)} \left(\frac{\rho + \delta_c}{1 - \delta_c} \right) \frac{k_{ic}}{m_c(\theta_c)}.$$

A.2.4 Firm-level Outcomes

Upon entry, the firm starts with zero workers but immediately recruits workers to achieve its optimal size in the following period.

Let $l_{ic}^T(\varphi) = l_{ic}(\varphi) + l_{ic}^F(\varphi)$ denote the firm's optimal employment size, where $l_{ic}(\varphi)$ is the optimal employment of production workers and $l_{ic}^F(\varphi) = f_{icc} + \sum_n I_{icn}(\varphi) f_{icn}$ is the mass of non-production workers, given a set of export decisions $I_{icn}(\varphi)$ for all n . The expected profits of the firm upon entry can then be written as:

$$\Pi_{ic}(0; \varphi) = \frac{1}{1 + \rho} \left[-\frac{k_{ic}}{m_c(\theta_c)} l_{ic}^T(\vartheta) + (1 - \delta_c) \Pi_{ic}(\varphi) \right], \quad (53)$$

where

$$\Pi_{ic}(\varphi) = \frac{1}{1 + \rho} \left[r_{ic}(\varphi) - w_{ic} l_{ic}^T(\varphi) + (1 - \delta_c) \Pi_{ic}(\varphi) \right] \quad (54)$$

is the value function of the vacancy posting problem evaluated at the firm's (constant) optimal employment size. That is, $\Pi_{ic}(\varphi) = \Pi_{ic}(l_{ic}(\varphi); \varphi)$ and $r_{ic}(\varphi) = r_{ic}(l_{ic}(\varphi); \varphi)$, after a slight abuse of notation. Using (54) to rewrite (53) yields

$$\Pi_{ic}(0; \varphi) = \frac{1}{1 + \rho} \left[-\frac{k_{ic}}{m_c(\theta_c)} l_{ic}^T(\varphi) + \left(\frac{1 - \delta_c}{\rho + \delta_c} \right) (r_{ic}(\varphi) - w_{ic} l_{ic}^T(\varphi)) \right]. \quad (55)$$

We can now define the cost of labor in industry i of city c , denoted μ_{ic} , as

$$\mu_{ic} = w_{ic} + \left(\frac{\rho + \delta_c}{1 - \delta_c} \right) \frac{k_{ic}}{m_c(\theta_c)}. \quad (56)$$

μ_{ic} can be interpreted as the per-period cost of hiring an additional worker in industry i of city c . To see this, use (56) to rewrite (55) as

$$\Pi_{ic}(0; \varphi) = \frac{(1 - \delta_c)}{(1 + \rho)(\rho + \delta_c)} \left[r_{ic}(\varphi) - \mu_{ic} l_{ic}^T(\varphi) \right]. \quad (57)$$

Using the definition of $l_{ic}^T(\varphi)$, we can now define the per-period profits of the firm (gross of the entry cost) as

$$\pi_{ic}(\varphi) = r_{ic}(\varphi) - \mu_{ic} l_{ic}(\varphi) - \mu_{ic} \sum_n I_{icn}(\varphi) f_{icn}. \quad (58)$$

Note that (56), (52) and the revenue equation (44) imply

$$\mu_{ic} = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right) \frac{r_{ic}(\varphi)}{l_{ic}(\varphi)}. \quad (59)$$

Substituting this into (58), we can rewrite the per-period profit function as in the main text,

$$\pi_{ic}(\varphi) = \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) r_{ic}(\varphi) - \mu_{ic} \sum_n I_{icn}(\varphi) f_{icn}. \quad (60)$$

Equations (44) and (59) allow us to compute the firm's optimal employment of production workers in terms of μ_{ic}

$$l_{ic}(\varphi) = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i} \frac{(\varphi)^{\sigma_i - 1}}{(\mu_{ic})^{\sigma_i}} \sum_n I_{icn}(\varphi) A_{in} (\tau_{icn})^{1 - \sigma_i}. \quad (61)$$

Using (59) and (61), yields the firm's per-period revenue

$$r_{ic}(\varphi) = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} \left(\frac{\varphi}{\mu_{ic}} \right)^{\sigma_i - 1} \sum_n I_{icn}(\varphi) A_{in} (\tau_{icn})^{1 - \sigma_i}. \quad (62)$$

Next, use (33) and (37) to obtain

$$p_{icn}(\varphi) = \frac{r_{icn}(\varphi) \tau_{icn}}{l_{icn}(\varphi) \varphi}.$$

Combining this with (59) yields the profit maximizing price in terms of μ_{ic}

$$p_{icn}(\varphi) = \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \right) \left(\frac{\mu_{ic}}{\varphi} \right) \tau_{icn}. \quad (63)$$

A.3 Entry

A.3.1 The Cost of Entry

In order to discover its productivity, the firm commits to an investment that requires hiring f_e workers upon entry and in each subsequent period with probability $1 - \delta_c$. This setting ensures that the per-period cost of an entry worker is equal to the per-period cost of hiring production workers, a standard property in frictionless trade models.

The present value of the entry cost can be written as

$$\frac{1}{1 + \rho} \left[\frac{k_{ic}}{m_c(\theta_c)} f_e + \left(\frac{1 - \delta_c}{1 + \rho} \right) f_e w_{ic} + \left(\frac{1 - \delta_c}{1 + \rho} \right)^2 f_e w_{ic} + \left(\frac{1 - \delta_c}{1 + \rho} \right)^3 f_e w_{ic} + \dots \right].$$

Rearranging terms yields

$$\frac{f_e}{1 + \delta_c} \left(\frac{1 - \delta_c}{\rho + \delta_c} \right) \left[w_{ic} + \frac{k_{ic}}{m_c(\theta_c)} \left(\frac{\rho + \delta_c}{1 - \delta_c} \right) \right].$$

Using (56), the present value of the entry cost can be written as a function of the local cost of labor, μ_{ic} ,

$$\frac{(1 - \delta_c)}{(1 + \rho)(\rho + \delta_c)} f_e \mu_{ic}.$$

A.3.2 The Free Entry Condition

Under free entry, the expected profits are equal to the present value of the entry cost. Using (57) and (58), the free entry condition can be written as

$$\frac{(1 - \delta_c)}{(1 + \rho)(\rho + \delta_c)} \int_0^\infty \pi_{ic}(\varphi) dG_{ic}(\varphi) = \frac{(1 - \delta_c)}{(1 + \rho)(\rho + \delta_c)} f_e \mu_{ic},$$

where $\pi_{ic}(\varphi)$ is per-period profit. Substituting the revenue function (62) into the per-period profit function (60) and imposing $I_{icn}(\varphi) = 1$ if $\varphi \geq \varphi_{icn}^*$, the free entry condition becomes

$$f_{ic}^e \mu_{ic} = \sum_n \int_{\varphi_{icn}^*}^\infty \left[\left(\frac{(\sigma_i - \beta_i) \tau_{icn} \mu_{ic}}{(\sigma_i - 1)} \right)^{1 - \sigma_i} A_{in}(\varphi)^{\sigma_i - 1} \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) - f_{icn} \mu_{ic} \right] dG_{ic}(\varphi).$$

Using the cutoff condition in destination n (equation (12) in the main text), we obtain

$$f_{ic}^e = \sum_n \int_{\varphi_{icn}^*}^\infty f_{icn} \left[\left(\frac{\varphi}{\varphi_{icn}^*} \right)^{\sigma_i - 1} - 1 \right] dG_{ic}(\varphi).$$

Assume that $G_{ic}(\varphi)$ is a Pareto distribution, with shape parameter κ_i and lower bound $\varphi_{min,ic}$. If $\kappa_i > \sigma_i - 1$, then the integral has a closed-form solution. In this case, the free entry condition simplifies to

$$f_{ic}^e = \frac{(\sigma_i - 1)}{(\kappa_i - \sigma_i + 1)} \sum_n f_{icn} \left(\frac{\varphi_{min,ic}}{\varphi_{icn}^*} \right)^{\kappa_i}. \quad (64)$$

A.4 Gravity

Bilateral exports from city c to destination n in industry i can be decomposed into the mass of exporting firms times average firm exports:

$$X_{icn} = \left(\frac{1 - G_{ic}(\varphi_{icn}^*)}{1 - G_{ic}(\varphi_{icc}^*)} \right) M_{ic} \int_{\varphi_{icn}^*}^{\infty} \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} \left(\frac{\varphi}{\mu_{ic}} \right)^{\sigma_i - 1} \frac{X_{in}}{(P_{in})^{1 - \sigma_i}} (\tau_{icn})^{1 - \sigma_i} \frac{dG_{ic}(\varphi)}{1 - G(\varphi_{icn}^*)},$$

using (62) to compute export revenue in n .

Under Pareto productivity, we obtain

$$X_{icn} = M_{ic} \left(\frac{\varphi_{icc}^*}{\varphi_{min,ic}} \right)^{\kappa_i} \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \tau_{icn} \mu_{ic} \right)^{1 - \sigma_i} \frac{X_{in}}{(P_{in})^{1 - \sigma_i}} \left(\frac{\kappa_i}{\kappa_i - \sigma_i + 1} \right) (\varphi_{min,ic})^{\kappa_i} (\varphi_{icn}^*)^{\sigma_i - \kappa_i - 1}. \quad (65)$$

We can further simplify (65) using the export cutoff condition (12) and the aggregate stability condition; i.e. $\delta_c M_{ic} = [1 - G_{ic}(\varphi_{icc}^*)] M_{ic}^e$. This yields the standard decomposition of bilateral exports into the extensive and intensive margins of trade,

$$X_{icn} = \frac{M_{ic}^e}{\delta_c} \left(\frac{\varphi_{min,ic}}{\varphi_{icn}^*} \right)^{\kappa_i} \mu_{ic} f_{icn} \left(\frac{\sigma_i - \beta_i}{1 - \beta_i} \right) \left(\frac{\kappa_i}{\kappa_i - \sigma_i + 1} \right). \quad (66)$$

For estimation purposes, it is convenient to work with the share of exports in sectoral revenue, X_{icF}/R_{ic} , where

$$R_{ic} \equiv \sum_v X_{icv} = \frac{M_{ic}^e}{\delta_c} \mu_{ic} \left(\frac{\sigma_i - \beta_i}{1 - \beta_i} \right) \left(\frac{\kappa_i}{\kappa_i - \sigma_i + 1} \right) \sum_v \left(\frac{\varphi_{min,ic}}{\varphi_{icv}^*} \right)^{\kappa_i} f_{icv}.$$

Therefore,

$$\frac{X_{icn}}{R_{ic}} = \frac{\left(\frac{\varphi_{min,ic}}{\varphi_{icn}^*} \right)^{\kappa_i} f_{icn}}{\sum_v \left(\frac{\varphi_{min,ic}}{\varphi_{icv}^*} \right)^{\kappa_i} f_{icv}}.$$

Using free entry condition (64), the export share simplifies to

$$\frac{X_{icn}}{R_{ic}} = \left(\frac{\sigma_i - 1}{\kappa_i - \sigma_i + 1} \right) \frac{f_{icn}}{f_{ic}^e} \left(\frac{\varphi_{min,ic}}{\varphi_{icn}^*} \right)^{\kappa_i}.$$

Finally, imposing the export cutoff condition (12), we obtain the local gravity equation (14) in the main text,

$$\frac{X_{icn}}{R_{ic}} = \left(\frac{\sigma_i - 1}{\kappa_i - \sigma_i + 1} \right) \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right)^{\frac{\kappa_i \sigma_i}{\sigma_i - 1}} (\varphi_{min,ic})^{\kappa_i} \frac{(f_{icn})^{\frac{\sigma_i - 1 - \kappa_i}{\sigma_i - 1}}}{f_{ic}^e} (A_{in})^{\frac{\kappa_i}{\sigma_i - 1}} (\tau_{icn})^{-\kappa_i} (\mu_{ic})^{\frac{-\kappa_i \sigma_i}{\sigma_i - 1}}.$$

A.5 Labor Demand and Supply

The stationary demand for production workers in industry i of city c can be computed as the sum of destination-specific labor demands for producers serving destination n :

$$\sum_n M_{ic} \frac{1 - G_{ic}(\varphi_{icn}^*)}{1 - G_{ic}(\varphi_{icc}^*)} \left[\int_{\varphi_{icn}^*}^{\infty} l_{icn}(\varphi) \frac{dG_{ic}(\varphi)}{1 - G_{ic}(\varphi_{icn}^*)} \right], \quad (67)$$

where the demand for workers producing output for n in firm φ , $l_{icn}(\varphi)$, is obtained from (61) by setting $I_{icn}(\varphi) = 1$ and $I_{icv}(\varphi) = 0$ for $v \neq n$. The term in brackets in (67) is then the average destination-specific demand for production workers across firms serving n .

Under Pareto productivity, we can evaluate the integral in (67) and obtain

$$M_{ic} \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i} \kappa_i \left[\sum_n \frac{X_{in}}{(P_{in})^{1-\sigma_i}} \frac{(\tau_{icn})^{1-\sigma_i}}{(\mu_{ic})^{\sigma_i}} (\varphi_{icc}^*)^{\kappa_i} \frac{(\varphi_{icn}^*)^{\sigma_i - \kappa_i - 1}}{\kappa_i - \sigma_i + 1} \right].$$

Using the export cutoff conditions yields a simplified expression for the demand for production workers

$$M_{ic} \frac{(\sigma_i - 1)\kappa_i}{(\kappa_i - \sigma_i + 1)(1 - \beta_i)} \sum_n \left(\frac{\varphi_{icc}^*}{\varphi_{icn}^*} \right)^{\kappa_i} f_{icn}.$$

In turn, the industry's stationary labor demand due to fixed and entry costs is:²⁷

$$\frac{M_{ic}}{1 - G_{ic}(\varphi_{icc}^*)} f_{ic}^e + \sum_n M_{ic} \left[\frac{1 - G_{ic}(\varphi_{icn}^*)}{1 - G_{ic}(\varphi_{icc}^*)} \right] f_{icn}.$$

Next, we show that M_{ic}^e , the mass of entrants, is proportional to L_{ic} , the mass of workers that are successfully matched in the industry. Equating L_{ic} to the aggregate labor demand in industry i of city c under Pareto productivity yields

$$L_{ic} = M_{ic} \left[\sum_n \left(\frac{\varphi_{icc}^*}{\varphi_{icn}^*} \right)^{\kappa_i} f_{icn} \left(\frac{(\sigma_i - 1)\kappa_i}{(\kappa_i - \sigma_i + 1)(1 - \beta_i)} + 1 \right) + \frac{f_{ic}^e}{\left(\frac{\varphi_{min,ic}}{\varphi_{icc}^*} \right)^{\kappa_i}} \right].$$

Imposing the free entry condition (64) and the aggregate stability condition $\delta_c M_{ic} = [1 - G_{ic}(\varphi_{icc}^*)] M_{ic}^e$, we obtain:

$$M_{ic}^e = \frac{\delta_c}{\kappa_i f_{ic}^e} \left[\frac{1}{1 - \beta_i} + \frac{1}{\sigma_i - 1} \right]^{-1} L_{ic}. \quad (68)$$

²⁷It is straightforward to verify that, under the entry protocol described in section A.3.1, the industry's demand for entry workers is equal to $M_{ic}^e f_{ic}^e / \delta_c$ in the stationary equilibrium.

A.6 Price Index

The price index in industry i of city c can be expressed as follows:

$$P_{in}^{1-\sigma_i} = \sum_v M_{iv} \left[\frac{1 - G_{iv}(\varphi_{inv}^*)}{1 - G_{iv}(\varphi_{ivv}^*)} \right] \int_{\varphi_{ivv}^*}^{\infty} p_{ivn}(\varphi)^{1-\sigma_i} dG_{iv}(\varphi | \varphi \geq \varphi_{inv}^*).$$

Substituting optimal firm prices (63) and imposing Pareto productivity yields:

$$P_{in}^{1-\sigma_i} = \frac{\kappa_i}{\kappa_i - \sigma_i + 1} \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \right)^{1-\sigma_i} \sum_v M_{iv} (\varphi_{ivv}^*)^{\kappa_i} (\varphi_{ivn}^*)^{\sigma_i - \kappa_i - 1} (\mu_{iv} \tau_{ivn})^{1-\sigma_i}.$$

Using the export cutoff condition, the price index becomes

$$P_{in}^{-\kappa_i} = \frac{\kappa_i}{\kappa_i - \sigma_i + 1} \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \right)^{-\kappa_i} \left(\frac{\sigma_i - \beta_i}{1 - \beta_i} \right)^{1 - \frac{\kappa_i}{\sigma_i - 1}} \sum_v M_{iv} (\varphi_{ivv}^*)^{\kappa_i} (\mu_{iv} \tau_{ivn})^{-\kappa_i} \left(\frac{\mu_{iv} f_{ivn}}{X_{in}} \right)^{1 - \frac{\kappa_i}{\sigma_i - 1}}. \quad (69)$$

A.7 Trade Share

From (66), the share of total income of location n spent on goods from city c in industry i can be expressed as:

$$\lambda_{icn} = \frac{X_{icn}}{\sum_v X_{ivn}} = \frac{\delta_c^{-1} M_{ic}^e f_{icn} \mu_{ic} \left(\frac{\varphi_{min,ic}}{\varphi_{icn}^*} \right)^{\kappa_i}}{\sum_v \delta_{iv}^{-1} M_{iv}^e f_{ivn} \mu_{iv} \left(\frac{\varphi_{min,iv}}{\varphi_{ivn}^*} \right)^{\kappa_i}}.$$

Using (68),

$$\lambda_{icn} = \frac{L_{ic} \left(\frac{f_{icn}}{f_{ic}^e} \right) \mu_{ic} (\varphi_{icn}^*)^{-\kappa_i} (\varphi_{min,ic})^{\kappa_i}}{\sum_v L_{iv} \left(\frac{f_{ivn}}{f_{iv}^e} \right) \mu_{iv} (\varphi_{ivn}^*)^{-\kappa_i} (\varphi_{min,iv})^{\kappa_i}}.$$

Using export cutoff conditions, city c 's trade share in location n 's expenditure on good i can be written as:

$$\lambda_{icn} = \frac{\left(\frac{L_{ic}}{f_{ic}^e} \right) (f_{icn})^{1 - \frac{\kappa_i}{\sigma_i - 1}} (\mu_{ic})^{1 - \frac{\kappa_i \sigma_i}{\sigma_i - 1}} (\varphi_{min,ic})^{\kappa_i} (\tau_{icn})^{-\kappa_i}}{\sum_v \left(\frac{L_{iv}}{f_{iv}^e} \right) (f_{ivn})^{1 - \frac{\kappa_i}{\sigma_i - 1}} (\mu_{iv})^{1 - \frac{\kappa_i \sigma_i}{\sigma_i - 1}} (\varphi_{min,iv})^{\kappa_i} (\tau_{ivn})^{-\kappa_i}}.$$

A.8 Welfare

From (32), the welfare of the normative representative consumer in any location n can be written as

$$V_n = (\rho)^{-1} \prod_{i=1}^I (\alpha_i)^{\alpha_i} \frac{\sum_{i=1}^I L_{in} w_{in}}{\prod_{i=1}^I (P_{in})^{\alpha_i}},$$

where $W_n = \sum_{i=1}^I L_{in} w_{in}$ since, net of entry costs, aggregate profits are zero.

Next, we rewrite the price index (69) using (i) the stability condition and (68) to express the mass of firms as a function of the labor allocation,²⁸ and (ii) $X_{in} = \alpha_i W_n$, an implication of the Cobb-Douglas assumption:

$$P_{in}^{-\kappa_i} = \frac{\left(\frac{\sigma_i - \beta_i}{\sigma_i - 1}\right)^{-\kappa_i} \left(\frac{\sigma_i - \beta_i}{1 - \beta_i}\right)^{1 - \frac{\kappa_i}{\sigma_i - 1}} \sum_v \left[\left(\frac{L_{iv}}{f_{iv}^e}\right) (\varphi_{min,vi}^*)^{\kappa_i} (\tau_{ivn})^{-\kappa_i} (\mu_{iv})^{1 - \frac{\kappa_i \sigma_i}{\sigma_i - 1}} (f_{ivn})^{1 - \frac{\kappa_i}{\sigma_i - 1}} \right]}{(\kappa_i - \sigma_i + 1) \left[\frac{1}{1 - \beta_i} + \frac{1}{\sigma_i - 1} \right] (\alpha_i W_n)^{1 - \frac{\kappa_i}{\sigma_i - 1}}}.$$

In turn, the *domestic* trade share of industry i in location n can be expressed as:

$$\lambda_{inn} = \frac{\left(\frac{L_{in}}{f_{in}^e}\right) (f_{inn})^{1 - \frac{\kappa_i}{\sigma_i - 1}} (\mu_{in})^{1 - \frac{\kappa_i \sigma_i}{\sigma_i - 1}} (\varphi_{min,in})^{\kappa_i}}{\sum_v \left[\left(\frac{L_{iv}}{f_{iv}^e}\right) (f_{inv})^{1 - \frac{\kappa_i}{\sigma_i - 1}} (\mu_{iv})^{1 - \frac{\kappa_i \sigma_i}{\sigma_i - 1}} (\varphi_{min,iv})^{\kappa_i} (\tau_{ivn})^{-\kappa_i} \right]}.$$

We can now express price index as a function of λ_{inn} :

$$P_{in} = \left[\frac{\lambda_{inn} (\alpha_i W_n)^{1 - \frac{\kappa_i}{\sigma_i - 1}} (\kappa_i - \sigma_i + 1) \left[\frac{1}{1 - \beta_i} + \frac{1}{\sigma_i - 1} \right]}{\left(\frac{\sigma_i - \beta_i}{1 - \beta_i}\right)^{1 - \frac{\kappa_i}{\sigma_i - 1}} \left(\frac{L_{in}}{f_{in}^e}\right) (f_{inn})^{1 - \frac{\kappa_i}{\sigma_i - 1}}} \right]^{\frac{1}{\kappa_i}} \frac{(\mu_{in})^{\frac{\sigma_i}{\sigma_i - 1} - \frac{1}{\kappa_i}}}{(\varphi_{min,in})} \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1}\right).$$

For analytical tractability, suppose that k_{ic} , the cost of posting vacancies in city c , is small in all industries. Thus (56) implies $\mu_{ic} \approx w_c$ for all i . The price index can then be approximated as follows:

$$P_{in} \approx \left[\frac{\lambda_{inn} \left(\alpha_i \sum_j L_{jn}\right)^{1 - \frac{\kappa_i}{\sigma_i - 1}} (\kappa_i - \sigma_i + 1) \left[\frac{1}{1 - \beta_i} + \frac{1}{\sigma_i - 1} \right]}{\left(\frac{\sigma_i - \beta_i}{1 - \beta_i}\right)^{1 - \frac{\kappa_i}{\sigma_i - 1}} \left(\frac{L_{in}}{f_{in}^e}\right) (f_{inn})^{1 - \frac{\kappa_i}{\sigma_i - 1}}} \right]^{\frac{1}{\kappa_i}} \frac{w_n}{\varphi_{min,in}} \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1}\right). \quad (70)$$

Consider the effects of an arbitrary shock to the vector of variable trade costs, $\{\tau_{ivn}\}$ for any industry i and any two different locations n and v , on the welfare of city c . For any endogenous variable x , let \dot{x} denote the ratio of x after the shock to x before the shock; i.e.

²⁸ $M_{iv} = \left(\frac{\varphi_{min,iv}}{\varphi_{ivv}}\right)^{\kappa_i} \frac{L_{iv}}{\kappa_i f_{iv}^e} \left[\frac{1}{1 - \beta_i} + \frac{1}{\sigma_i - 1} \right]^{-1}$.

the proportional change in the stationary equilibrium value of x .

Aggregate income satisfies $W_c \approx w_c \left(\sum_{i=1}^I L_{ic} \right) = w_c e_c \bar{L}_c$, where e_c is the employment rate and \bar{L}_c is the endowment of labor in city c . Therefore, $\dot{W}_c \approx \dot{e}_c \dot{w}_c$. The proportional change in welfare is

$$\dot{V}_c \approx \frac{\dot{e}_c \dot{w}_c}{\prod_{i=1}^I \left(\dot{P}_{ic} \right)^{\alpha_i}}. \quad (71)$$

Let η_{ic} denote the employment share of industry i in city c . Then, $\dot{L}_{ic} = \eta_{ic} \dot{e}_c$. From (70), we can thus approximate the proportional change in the price index as

$$\dot{P}_{ic} \approx \left(\frac{\dot{\lambda}_{icc}}{\dot{\eta}_{ic}} \right)^{\frac{1}{\varepsilon_i}} (\dot{e}_n)^{-\Upsilon_i} \dot{w}_c,$$

where $\Upsilon_i \equiv \frac{1}{\sigma_i - 1}$ and $\varepsilon_i \equiv \kappa_i$ is the trade elasticity. Substituting this expression into (71), we obtain:

$$\dot{V}_c \approx (\dot{e}_c)^{1 + \sum_{i=1}^I -\alpha_i \Upsilon_i} \prod_{i=1}^I \left(\frac{\dot{\lambda}_{icc}}{\dot{\eta}_{ic}} \right)^{-\frac{\alpha_i}{\varepsilon_i}}.$$

A.9 Special Case: Monopolistic Competition, Free Entry and Homogenous Firms (MC-FE-HOM)

In this section, we impose a degenerate productivity distribution. In particular, we assume that the labor productivity of *all* firms in any industry i of any location n is equal to φ_{in} . Moreover, we assume $f_{ivn} = 0 = f_{iv}^e$. Instead, there is a fixed startup cost f_{in} that depends on the industry and location of the producer. Note that, in this setting, every firm in any cell in exports to every destination.

A.9.1 Firm Level Outcomes and Zero-Profit Condition

From (63), the profit maximizing price that firms in industry i of city c set in destination n is

$$p_{ivn} = \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \right) \frac{\mu_{iv}}{\varphi_{iv}} \tau_{ivn}. \quad (72)$$

From (62), destination-specific firm revenue can be written as:

$$r_{icn} = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} \left(\frac{\varphi_{ic}}{\mu_{ic}} \right)^{\sigma_i - 1} A_{in} (\tau_{icn})^{1 - \sigma_i}. \quad (73)$$

Let $r_{ic} \equiv \sum_n r_{icn}$ denote total firm revenue. From (57) and (59), expected profits upon entry can be expressed as:

$$\Pi_{ic}(0; \varphi_{ic}) = \frac{(1 - \delta_c)}{(1 + \rho)(\rho + \delta_c)} \left[r_{ic} \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) - \mu_{ic} f_{ic} \right].$$

Due to free entry in any industry i of city c , the zero-profit condition thus requires:

$$r_{ic} \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) = \mu_{ic} f_{ic}. \quad (74)$$

A.9.2 Gravity

Computing bilateral exports $X_{icn} \equiv M_{ic} r_{icn}$ and sectoral revenue R_{ic} , we obtain the export share:

$$\frac{X_{icn}}{R_{ic}} = \frac{A_{in} (\tau_{icn})^{1 - \sigma_i}}{\sum_n A_{in} (\tau_{icn})^{1 - \sigma_i}}.$$

Using the zero-profit condition to rewrite the denominator yields

$$\frac{X_{icn}}{R_{ic}} = A_{in} \left(\frac{\tau_{icn}}{\varphi_{ic}} \right)^{1 - \sigma_i} \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} (\mu_{ic})^{-\sigma_i} (f_{ic})^{-1}.$$

Note that $\sigma_i - 1$ is the trade elasticity.

A.9.3 Labor Demand and Supply

The demand for production workers in cell ic is $M_{ic} l_{ic}$, where firm employment follows from (61). Labor demand from fixed costs is simply $M_{ic} f_{ic}$. Hence we obtain:

$$L_{ic} = M_{ic} \left[\left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i} \frac{(\varphi_{ic})^{\sigma_i - 1}}{(\mu_{ic})^{\sigma_i}} \sum_n A_{in} (\tau_{icn})^{1 - \sigma_i} + f_{ic} \right]. \quad (75)$$

Using the zero-profit condition (74), yields a proportional link between the mass of producers and the mass of workers in the industry:

$$L_{ic} = M_{ic} f_{ic} \left[\frac{\sigma_i - \beta_i}{1 - \beta_i} \right]. \quad (76)$$

A.9.4 Price Index

The price index is:

$$(P_{in})^{1 - \sigma_i} = \sum_v M_{iv} (p_{ivn})^{1 - \sigma_i}.$$

Using (72), the price index can be expressed as

$$(P_{in})^{1-\sigma_i} = \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \right)^{1-\sigma_i} \sum_v M_{iv} \left(\frac{\mu_{iv}}{\varphi_{iv}} \right)^{1-\sigma_i} (\tau_{ivn})^{1-\sigma_i}. \quad (77)$$

A.9.5 Trade Share

The trade share is

$$\lambda_{icn} \equiv \frac{X_{icn}}{X_{in}} = \frac{M_{ic} r_{icn}}{\sum_v X_{ivn}}.$$

From revenue (73), the domestic trade share can be expressed as

$$\lambda_{inn} = \frac{M_{in} \left(\frac{\varphi_{in}}{\mu_{in}} \right)^{\sigma_i - 1}}{\sum_v M_{iv} \left(\frac{\varphi_{iv}}{\mu_{iv}} \right)^{\sigma_i - 1} (\tau_{ivn})^{1-\sigma_i}}. \quad (78)$$

A.9.6 Welfare

Using (76) and (78), the price index (77) in industry i of city c can be written as a function of the domestic trade share:

$$P_{ic} = (\lambda_{icc})^{\frac{1}{\sigma_i - 1}} \left(\frac{L_{ic}}{f_{ic}} \right)^{\frac{1}{1-\sigma_i}} \left[\left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right) \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} (\varphi_{ic})^{\sigma_i - 1} \right]^{-1} \mu_{ic}. \quad (79)$$

If the cost of posting vacancies in city c , k_{ic} is small in all industries, then $\dot{w}_c \approx \dot{\mu}_{ic}$ in all industries. From (79),

$$\left(\frac{\dot{w}_c}{\dot{P}_{ic}} \right) \approx \left(\frac{\dot{\lambda}_{icc}}{\dot{L}_{ic}} \right)^{\frac{1}{1-\sigma_i}}. \quad (80)$$

From (71) and (80),

$$\dot{V}_c = \dot{e}_c \prod_{i=1}^I \left(\frac{\dot{\lambda}_{icc}}{\dot{L}_{ic}} \right)^{\frac{\alpha_i}{1-\sigma_i}}.$$

Let $\Upsilon_i \equiv \frac{1}{\varepsilon_i}$, where $\varepsilon_i \equiv \sigma_i - 1$ is the trade elasticity. Then, using $\dot{L}_{ic} = \dot{\eta}_{ic} \dot{e}_c$, the welfare gains from trade can be approximated as follows:

$$\dot{V}_c \approx (\dot{e}_c)^{1 + \sum_{i=1}^I \alpha_i \Upsilon_i} \prod_{i=1}^I \left(\frac{\dot{\lambda}_{icc}}{\dot{\eta}_{ic}} \right)^{-\frac{\alpha_i}{\varepsilon_i}}.$$

A.10 Special Case: Monopolistic Competition and Restricted Entry (MC-RE)

In the context of the model of the previous section, here we abandon the free entry condition. In particular, we follow the setup in [Arkolakis et al. \(2012\)](#), where the mass of producers, M_{in} , is fixed and $f_{in} = 0$ for all i and n . A distinct feature of this market structure is that aggregate profits are positive and thus need to be accounted for in the welfare analysis. We assume that profits are distributed back to the representative consumer.

Aggregate income in city c can be written as:

$$W_c = \sum_{i=1}^I [L_{ic}w_{ic} + M_{ic}\Pi_{ic}(0, \varphi_{ic})], \quad (81)$$

where,

$$\Pi_{ic}(0, \varphi_{ic}) = \frac{(1 - \delta_c)}{(1 + \rho)(\rho + \delta_c)} r_{ic} \left(\frac{1 - \beta_i}{\sigma_i - \beta_i} \right),$$

and r_{ic} is defined as in section A.9.1. From (75), since now we have $f_{ic} = 0$ for all i and c ,

$$L_{ic} = M_{ic} \sum_n l_{icn}, \quad (82)$$

where,

$$l_{icn} = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i} A_{in} (\tau_{icn})^{1-\sigma_i} \frac{(\varphi_{ic})^{\sigma_i-1}}{(\mu_{ic})^{\sigma_i}}.$$

From (73), revenue can be written as a function of l_{icn} :

$$r_{icn} = \left(\frac{\sigma_i - \beta_i}{\sigma_i - 1} \right) \mu_{ic} l_{icn}.$$

Since $r_{ic} = \sum_n r_{icn}$, we can use (82) to write aggregate profits as a function of the mass of workers employed in cell ic :

$$M_{ic}\Pi_{ic}(0, \varphi_{ic}) = \frac{(1 - \delta_c)(1 - \beta_i)}{(1 + \rho)(\rho + \delta_c)(\sigma_i - 1)} \mu_{ic} L_{ic}.$$

Substituting this equation into aggregate income (81) yields

$$W_c = \sum_{i=1}^I \left[L_{ic}w_{ic} + \frac{(1 - \delta_c)(1 - \beta_i)}{(1 + \rho)(\rho + \delta_c)(\sigma_i - 1)} \mu_{ic} L_{ic} \right].$$

As before, we assume that the cost of posting vacancies in city c , k_{ic} is small in all industries.

This implies that $\mu_{ic} \approx w_c \forall i$. In addition, we now assume small cross-industry differences in $\beta_i \approx \beta$ and $\sigma_i \approx \sigma \forall i$.²⁹ Under these assumptions,

$$W_c \approx \left[1 + \frac{(1 - \delta_c)(1 - \beta)}{(1 + \rho)(\rho + \delta_c)(\sigma - 1)} \right] w_c \sum_{i=1}^I L_{ic}. \quad (83)$$

Using (83), we have:

$$\dot{V}_c = \frac{\dot{W}_c}{\prod_{i=1}^I (\dot{P}_{ic})^{\alpha_i}} \approx \prod_{i=1}^I \left(\frac{\dot{w}_c}{\dot{P}_{ic}} \right)^{\alpha_i} \dot{e}_c. \quad (84)$$

From (77) and (78), the price index can be expressed as:

$$(P_{ic})^{1-\sigma_i} = (\lambda_{icc})^{-1} M_{ic} \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right)^{\sigma_i - 1} \left(\frac{\varphi_{ic}}{\mu_{ic}} \right)^{\sigma_i - 1}.$$

Therefore,

$$\left(\frac{\dot{\mu}_{ic}}{\dot{P}_{ic}} \right) \approx \left(\frac{\dot{w}_c}{\dot{P}_{ic}} \right) = \left(\lambda_{icc} \right)^{\frac{1}{1-\sigma_i}}. \quad (85)$$

Combining (85) and (84) yields

$$\dot{V}_c \approx \dot{e}_c \prod_{i=1}^I \left(\lambda_{icc} \right)^{-\frac{\alpha_i}{\varepsilon_i}},$$

where, as we show next, $\varepsilon_i \equiv \sigma_i - 1$ is the trade elasticity in this model.

A.10.1 Gravity with Restricted Entry

As in the previous section,

$$\frac{X_{icn}}{R_{ic}} = \frac{A_{in} (\tau_{icn})^{1-\sigma_i}}{\sum_{n'} A_{in'} (\tau_{icn'})^{1-\sigma_i}}.$$

From (82),

$$\left[\sum_{n'} A_{in} (\tau_{icn})^{1-\sigma_i} \right]^{-1} = \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right) \frac{M_{ic}}{L_{ic}} (\varphi_{ic})^{\sigma_i - 1} (\mu_{ic})^{-\sigma_i}.$$

Hence we obtain:

$$\frac{X_{icn}}{R_{ic}} = A_{in} \left(\frac{\sigma_i - 1}{\sigma_i - \beta_i} \right) \frac{M_{ic}}{L_{ic}} (\varphi_{ic})^{\sigma_i - 1} (\tau_{icn})^{1-\sigma_i} (\mu_{ic})^{-\sigma_i}.$$

²⁹These assumptions ensure that aggregate profits are a constant fraction of revenues (and hence wage bill) in each sector. They thus play the same role as macro-level restriction R2(MS) in [Arkolakis et al. \(2012\)](#).

A.11 Perfect Competition (PC)

A.11.1 An Armington Model with Multiple Sectors and Search Frictions

Coming soon...

B Derivation of the Estimating Equations

B.1 Linear Approximation of the Unobservable Cost of Labor

In this section we derive the linear approximation to the unobservable cost of labor. Ultimately, the objective of the approximation is to express the gravity and revenue equations as a linear function of industry-city log wages. We take the linear approximation around the point where the cost of posting vacancies is small, i.e. where the unit cost of labor is constant and well approximated by wages. Let $x_0 = (w_{ic} = w_0, \{k_{ic}\}_i = 0, e_c = e_0)$ denote that point. The approximation is given by:

$$\begin{aligned}
\mu_{ic} &\approx (w_0 + \psi_c \cdot 0) + (w_{ic} - w_0) \left. \frac{\partial \mu_{ic}}{\partial w_{ic}} \right|_{x_0} + (k_{ic} - 0) \left. \frac{\partial \mu_{ic}}{\partial k_{ic}} \right|_{x_0} + (e_c - e_0) \left. \frac{\partial \mu_{ic}}{\partial e_c} \right|_{x_0} \\
&\approx w_0 + (w_{ic} - w_0) + k_{ic} \left(0 \cdot \left. \frac{\partial \psi_c}{\partial k_{ic}} \right|_{x_0} + \psi \right) + (e_c - e_0) \cdot 0 \cdot \left. \frac{\partial \psi_c}{\partial e_c} \right|_{x_0} \\
&\approx w_{ic} + \psi k_{ic},
\end{aligned} \tag{86}$$

where ψ is evaluated around x_0 , the point where k_{ic} is small. Specifically, $\psi = \left(\frac{\rho+\delta}{1-\delta}\right) \frac{1}{m(\theta)}$, where the vacancy-filling rate $m(\theta)$ is constant around x_0 . Note that at the expansion point, the unit costs are not a function of the employment rate e_c .

Subtracting an arbitrary constant \bar{w} , dividing by \bar{w} and adding the log of that constant, equation (86) can be rewritten as follows:

$$\ln \bar{w} + \frac{(\mu_{ic} - \bar{w})}{\bar{w}} \approx \ln \bar{w} + \frac{(w_{ic} - \bar{w})}{\bar{w}} + \psi \frac{k_{ic}}{\bar{w}} \tag{87}$$

Finally, noting that $\ln x \approx \ln z_0 + \frac{x-z_0}{z_0}$, where z_0 is an arbitrary constant around which the approximation is taken, we can relate the log unit cost to log industry-city wages:

$$\ln \mu_{ic} \approx \ln w_{ic} + \psi k, \tag{88}$$

where $\frac{k_{ic}}{\bar{w}}$.

B.2 Linear Approximation of the Wage Equation

The goal of the linear approximation is to link the industry-city wage to the industrial composition of the local labor market. Substituting equation (5) in equation (8) yields:

$$w_{ic} = \tilde{\gamma}_{1c}\bar{w}_c + \gamma_{2c}k_{ic}, \quad (89)$$

where $\bar{w}_c = \sum_i \eta_{ic}w_{ic}$, $\tilde{\gamma}_{1c} = \frac{\theta_c m_c(\theta_c)}{\rho + s + \theta_c m_c(\theta_c)}$, $\gamma_{2c} = \left(\frac{\beta}{1-\beta}\right) \left(\frac{\rho+s}{1-\delta}\right) \frac{1}{m_c(\theta_c)}$, and both parameters are dependent on the tightness of the labor market.

Solving for \bar{w}_c , we obtain:

$$\bar{w}_c = \frac{\gamma_{2c}}{1 - \tilde{\gamma}_{1c}} \sum_i \eta_{ic}k_{ic},$$

and substituting back into equation (89), the reduced-form wage equation can be written as:

$$\begin{aligned} w_{ic} &= \frac{\tilde{\gamma}_{1c} \cdot \gamma_{2c}}{1 - \tilde{\gamma}_{1c}} \sum_i \eta_{ic}k_{ic} + \gamma_{2c}k_{ic}, \\ &= \gamma_{1c} \sum_i \eta_{ic}k_{ic} + \gamma_{2c}k_{ic}, \end{aligned}$$

where $\gamma_{1c} = \frac{\tilde{\gamma}_{1c} \cdot \gamma_{2c}}{1 - \tilde{\gamma}_{1c}}$.

In order to take the linear approximation of w_{ic} , it is useful to decompose the vacancy posting cost k_{ic} , without loss of generality, as follows:

$$k_{ic} = \tilde{k}_i + \tilde{k}_c + \tilde{\xi}_{ic},$$

where \tilde{k}_i represents a common (across cities) industry component, \tilde{k}_c represents city-specific component, and $\tilde{\xi}_{ic}$ is an idiosyncratic component that sums to zero across industries, within cities (i.e. $\sum_i \tilde{\xi}_{ic} = 0$).

Using this decomposition of the vacancy posting cost, one can rewrite the wage equation as:

$$w_{ic} = \gamma_{1c}\tilde{K}_c + (\gamma_{1c} + \gamma_{2c})\tilde{k}_c + \gamma_{1c} \sum_i \eta_{ic}\tilde{\xi}_{ic} + \gamma_{2c}\tilde{k}_i + \gamma_{2c}\tilde{\xi}_{ic},$$

where $\tilde{K}_c = \sum_i \eta_{ic}\tilde{k}_i$ captures the weighted city-average of national-level recruiting costs.

Let $w_{ic} = w_{ic}(\tilde{K}_c, \{\tilde{k}_i\}_i, \tilde{k}_c, \{\tilde{\xi}_{ic}\}_i, e_c)$ describe the reduced-form equation. We take a linear

approximation of the wage equation around the point where recruitment costs are zero and the employment rate is the same across cities, i.e. around $x_0 = (\tilde{K}_c = 0, \{\tilde{k}_i\}_i = 0, \tilde{k}_c = 0, \{\tilde{\xi}_{ic}\}_i = 0, e_c = e_0)$. Around that point, cities have an identical industrial composition (i.e. $\eta_{ic} = 1/I$). The linear approximation is given by:

$$\begin{aligned}
w_{ic} &\approx (\gamma_1 \cdot 0 + \gamma_{2c} \cdot 0) + (\tilde{K}_c - 0) \frac{\partial w_{ic}}{\partial \tilde{K}_c} \Big|_{x_0} \\
&+ (\tilde{k}_c - 0) \frac{\partial w_{ic}}{\partial \tilde{k}_c} \Big|_{x_0} + (\tilde{k}_i - 0) \frac{\partial w_{ic}}{\partial \tilde{k}_i} \Big|_{x_0} + \sum_j (\tilde{\xi}_{jc} - 0) \frac{\partial w_{ic}}{\partial \tilde{\xi}_{jc}} \Big|_{x_0} + (e_c - e_0) \frac{\partial w_{ic}}{\partial e_c} \Big|_{x_0} \\
&= \gamma_1 \tilde{K}_c + (\gamma_1 + \gamma_2) \tilde{k}_c + \gamma_2 \tilde{k}_i + \gamma_1 \frac{1}{I} \sum_i \tilde{\xi}_{ic} + \gamma_2 \tilde{\xi}_{ic} \\
&+ (e_c - e_0) \left(0 \cdot \frac{\partial \gamma_{1c}}{\partial e_c} \Big|_{x_0} + 0 \cdot \frac{\partial \gamma_{2c}}{\partial e_c} \Big|_{x_0} + \gamma_1 \cdot \frac{\partial \tilde{K}_c}{\partial e_c} \Big|_{x_0} + \gamma_1 \sum_i \frac{\partial \eta_{ic}}{\partial e_c} \Big|_{x_0} \cdot 0 \right) \\
&\approx \gamma_1 \tilde{K}_c + (\gamma_1 + \gamma_2) \tilde{k}_c + \gamma_2 \tilde{k}_i + \gamma_2 \tilde{\xi}_{ic} + \gamma_1 (e_c - e_0) \frac{\partial \tilde{K}_c}{\partial e_c} \Big|_{x_0}, \tag{90}
\end{aligned}$$

where we have used the property that $\sum_i \tilde{\xi}_{ic} = 0$, and where γ_1 and γ_2 are constant parameters corresponding to γ_{1c} and γ_{2c} , evaluated at x_0 , respectively.

Collecting terms, equation (90) can be rewritten as:

$$w_{ic} \approx \tilde{\gamma}_0 + \gamma_1 \tilde{K}_c + \gamma_2 \tilde{k}_i + \gamma_3 \tilde{k}_c + \tilde{\gamma}_4 e_c + \gamma_2 \tilde{\xi}_{ic}, \tag{91}$$

where each of the $\tilde{\gamma}$ s are constant parameters obtained from the linear approximation. Specifically, $\tilde{\gamma}_0 = -\gamma_1 e_0 \frac{\partial \tilde{K}_c}{\partial e_c} \Big|_{x_0}$, $\gamma_3 = (\gamma_1 + \gamma_2)$ and $\tilde{\gamma}_4 = \gamma_1 \frac{\partial \tilde{K}_c}{\partial e_c} \Big|_{x_0}$.

Subtracting an arbitrary constant \bar{w} , dividing by \bar{w} and adding the log of that constant, we obtain the following approximation for log industry-city wages:

$$\ln w_{ic} \approx \gamma_0 + \gamma_1 \sum_i \eta_{ic} k_i + \gamma_2 k_i + \gamma_3 k_c + \gamma_4 e_c + \gamma_2 \xi_{ic}, \tag{92}$$

where $\ln w_{ic} \approx \ln \bar{w} + \frac{(w_{ic} - \bar{w})}{\bar{w}}$, $\gamma_0 = \ln \bar{w} + \frac{(\tilde{\gamma}_0 - \bar{w})}{\bar{w}}$, $\gamma_4 = \frac{\tilde{\gamma}_4}{\bar{w}}$, $k_i = \frac{\tilde{k}_i}{\bar{w}}$, $k_c = \frac{\tilde{k}_c}{\bar{w}}$ and $\xi_{ic} = \frac{\tilde{\xi}_{ic}}{\bar{w}}$.

Importantly, equation (92) shows that, at the national level, inter-industry wage differentials are given by $\gamma_2 k_i$, which expresses the average wage in industry i relative to an omitted group. Letting $\nu_i = \gamma_2 k_i$ denote the national industry wage premium, we finally express log

industry-city wages as a function of industrial composition:

$$\ln w_{ic} \approx \gamma_0 + \frac{\gamma_1}{\gamma_2} K_c + \gamma_2 k_i + \gamma_3 k_c + \gamma_4 e_c + \gamma_2 \xi_{ic}, \quad (93)$$

where $K_c = \sum_i \eta_{ic} \nu_i$ is an index that captures industrial composition at the city level.

C Additional Tables

C.1 Summary Statistics

Table 7: Establishment summary statistics, based on *all* establishments

Variable	Mean	Std. Dev.	Min.	Max.	N
Share of exporters	0.113	0.316	0	1	27845094
Share of exports in revenue (%).	2.45	10.954	0	100	27473071
Number of employees	13.197	91.05	1	55153	27859151
Median wage of full time workers	59.007	26.05	0.002	250.286	24514120
Log exports	12.174	2.2	4.600	23.698	2462180
Log revenue	13.001	1.471	6.764	24.04	23193914
Log number of employees	1.521	1.196	0	10.918	27859151
Log median wage	3.971	0.493	-6.28	5.523	24514120

Notes: Statistics are weighted using the LIAB survey weights. Values are deflated and expressed in Euros.

Table 8: Establishment and and employment variables, aggregated at the industry-city level

Variable	Mean	Std. Dev.	Min.	Max.	N
<i>Establishment variables (LIAB):</i>					
Log exports	18.91	2.142	9.548	25.329	9731
Log revenue	20.857	1.738	11.667	26.227	15595
Share of exports in revenue	0.125	0.186	0	1	15595
Share of exporters	0.293	0.383	0	1	16236
<i>Employment variable (SIAB):</i>					
Employment (SIAB)	351.004	485.422	20	6523	17822
Adjusted indXcity wage (SIAB)	-0.008	0.223	-1.021	0.498	17822

Notes: Establishment aggregates come from the LIAB data and weighted using the LIAB survey weights. Employment variables are constructed using the SIAB data. Adjusted wages are adjusted using Mincer regressions (see below for details).

C.2 Additional Robustness Checks

In this section, we investigate additional robustness exercises to probe the validity of our Bartik-type instruments by performing several specification checks suggested by [Goldsmith-Pinkham et al. \(2017\)](#). First, we assess the correlation between our instruments and characteristics of cities in the base year. In particular, we compute, by city, several variables aimed at capturing labour market conditions and city-skill in the base year. We then investigate the relationship between these variables and the base-period industrial structure. The idea is that if the instruments (through initial industry shares) are correlated with city characteristics in the base year, then any trend or shock that is correlated to those city characteristics could also be correlated with the instruments, therefore potentially violating the exclusion restriction we require for our instruments to be valid.

Table 7 contains the results of this exercise. In the first two columns, we regress the value of our within- and between-instruments in 1996 (the first year we can calculate the instruments) on shares of college-educated, female, and German workers and the log employment rate and size of the workforce, average over the period 1992-1993. In these two columns, only one coefficient is statistically significant but the variables are jointly significant.

Since our identification strategy rests on the assumption that the initial industrial structure is not correlated with the residual in our second-stage regressions, we investigate the relationship between the initial industrial structure and city characteristics. In column 3, we compute the first principle component of our 58 industrial categories (i.e. the component that explains most of the variance in industry shares) in the base year. The idea is simply to reduce the dimension of our industrial categories into a single dimension that we can regress on our vector of city characteristics. Finally, in columns 4 and 5 we repeat these exercises by simply splitting industries into durables and non-durables. While the base-year characteristics are rarely individually significant, we cannot reject that they are jointly correlated with initial industrial structure.

Since we cannot rule out that initial industrial structure is correlated with city-level labour market characteristics, we assess the robustness of our main specification to including additional city-level, base-year controls.

Table 8 estimates eight additional specifications to our main gravity equation. In columns 1-6, we include base-year, city-level characteristics, introducing them one at a time. Column 7 adds all five variables at once. Finally, in column 8, we interact each of the base-year characteristic with time trends. We find that our main coefficient estimates are remarkably robust to the inclusion of these additional controls. Table 9 repeats this exercise for our main specification of the revenue equation, and suggests similar robustness.

Table 9: Relationship between industry shares and city-specific characteristics

	IVB_{ct} 1996	IVW_{ct} 1996	Component 1 1992-1993	Non-durables 1992-1993	Durables 1992-1993
City-specific characteristics in 1992-1993:					
Share of college graduates	0.005 (0.003)	0.008 (0.008)	-0.194 (0.134)	0.771 (1.034)	-0.771 (1.034)
Share of females	-0.004 (0.003)	-0.017** (0.006)	-0.044 (0.144)	-0.347 (0.784)	0.347 (0.784)
Share of Germans	0.001 (0.002)	-0.005 (0.005)	-0.056 (0.146)	0.639 (0.643)	-0.639 (0.643)
Log employment rate	0.005 (0.003)	-0.009 (0.007)	0.748*** (0.181)	-0.571 (0.889)	0.571 (0.889)
Log workforce	-0.0001 (0.0002)	0.0002 (0.0002)	-0.081 (0.105)	0.027 (0.028)	-0.027 (0.028)
Observations	24	24	24	24	24
R-squared	0.618	0.519	0.909	0.450	0.450
F-stat	5.82	3.88	35.94	2.94	2.94
p-val > F-stat	0.00	0.01	0.00	0.04	0.04
Proportion			0.27		

Notes: IVW_{ct} corresponds to $\sum_i \hat{\eta}_{ict-1} \Delta \hat{\nu}_{it}$ and IVB_{ct} to $\sum_i \hat{\nu}_{it} \Delta \hat{\eta}_{ict}$. The term ‘Component 1’ refers to the first principal component of industry shares in 1992-1993. In column 3, the first principal component and the city-specific characteristics are standardized to have unit standard deviation. The term ‘Proportion’ refers to the proportion of the variance of industry shares explained by the first principal component. The term ‘Durables’ (‘Non-durables’) refers to the share of employment in industries that produce durable (non-durable) goods in 1992-1993. Standard errors in parentheses.

Table 10: Gravity robustness table: adding city-specific controls

Dependent variable	$\Delta \ln \left(\frac{X_{icFt}}{R_{ict}} \right)$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta \ln w_{ict}$	-5.711** (2.534)	-5.312** (2.516)	-5.824** (2.448)	-5.655** (2.417)	-6.383** (2.472)	-5.309** (2.524)	-5.362** (2.532)	-5.281** (2.476)
Share of college graduates	1.179*** (0.413)						-0.569 (0.950)	
Share of females		1.201*** (0.279)				1.191*** (0.381)	1.529** (0.659)	
Share of Germans			0.727** (0.305)				-0.269 (0.357)	
Log employment rate				-1.011** (0.363)		-0.011 (0.531)	-0.282 (0.642)	
Log workforce					0.014 (0.026)		0.001 (0.025)	
City controls*Linear trends	no	no	no	no	no	no	no	yes
Linear trends	no	no	no	no	no	no	no	yes
Industry-year FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	3713	3713	3713	3713	3713	3713	3713	3713
Hansen	0.633	0.708	0.732	0.696	0.692	0.707	0.740	0.757
F-statistics	34.86	38.24	35.55	36.83	33.34	38.07	37.81	37.25
AP p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: All tables use the baseline instruments. Both regressions are weighted using the number of establishments in an industry-city cell at (t-1). Standard errors, in parentheses, are clustered at the city level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level.

Table 11: Revenue robustness table: adding city-specific controls

Dependent variable	$\Delta \ln r_{ict}(\varphi)$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Elasticity of substitution in consumption (σ)	1.186** (0.476)	1.192** (0.473)	1.186** (0.476)	1.188** (0.474)	1.192** (0.474)	1.191** (0.473)	1.197** (0.474)	1.192** (0.482)
Share of college graduates	-2.781 (5.302)						21.694*** (3.611)	
Share of females		-42.862*** (7.934)				-31.083*** (8.556)	-13.194*** (2.882)	
Share of Germans			4.304 (5.563)				-16.072*** (2.028)	
Log employment rate				-55.120*** (13.904)		-21.200** (7.687)	-26.548*** (1.602)	
Log workforce					-0.682** (0.291)		-0.875*** (0.080)	
City controls*Linear trends	no	no	no	no	no	no	no	yes
Linear trends	no	no	no	no	no	no	no	yes
Establishment FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry-year FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	49711	49711	49711	49711	49711	49711	49711	49711
Hansen	0.500	0.499	0.500	0.497	0.501	0.498	0.493	0.476
F-statistics	14.72	14.72	14.72	14.72	14.72	14.72	14.72	14.83
AP p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: All tables use the baseline instruments. All columns are weighted using the establishment weights. Standard errors, in parentheses, are clustered at the city level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level.