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ABSTRACT

While the labor market implications of mergers have been historically ignored as "out of market" effects, recent actions by the Department of Justice (DOJ) place buyer market power (i.e., monopsony) at the forefront of antitrust policy. We develop a theory of multi-plant ownership and monopsony to help guide this new policy focus. We estimate the model using U.S. Census data and demonstrate the model's ability to replicate empirically documented paths of employment and wages following mergers. We then simulate a representative set of U.S. mergers in order to evaluate merger review thresholds. Our main exercise applies the DOJ and FTC's product market concentration thresholds to local labor markets. Assuming mergers generate efficiency gains of 5 percent, our simulations suggest that workers are harmed, on average, under the enforcement of the more lenient 2010 merger guidelines and unharmed, on average, under enforcement of the more stringent 1982 merger guidelines. We also provide a framework for further research evaluating alternative concentration thresholds based on assumptions about the efficiency effects of mergers and the resource constraints of regulators. Finally, we provide guidance for using the Gross Downward Wage Pressure method for evaluating the impact of mergers on labor markets.

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1 Introduction

In July 2021, the White House issued an executive order calling on antitrust agencies to (i) broadly increase enforcement and (ii) devote more efforts to curbing labor market power:

> "[I]t is the policy of my Administration to enforce the antitrust laws to combat the excessive concentration of industry, the abuses of market power, and the harmful effects of monopoly and monopsony — especially as these issues arise in labor markets..."
>
> - White House (2021)

Consequently, in November 2021, the Department of Justice sued to block the merger of Penguin Random House and Simon & Schuster on grounds of *"harm to American workers, in this case authors, through consolidation among buyers...referred to as 'monopsony'."* By November of 2022, Simon & Schuster scrapped their planned sale to Penguin Random House. Meanwhile, on January 18, 2022, the Department of Justice and the Federal Trade Commission issued a Request for Information on Merger Enforcement seeking public comment on plans for revising the Merger Guidelines, which asked, among other things, "How should the guidelines' analysis of monopsony power differ from its analysis of monopoly power?"

Given the sizable welfare losses from labor market power found in Berger, Herkenhoff, and Mongey (2022, henceforth BHM) and significant public interest in labor-related merger guidelines, this paper extends BHM to include multi-plant ownership. Our analysis yields several contributions: (i) we theoretically characterize the effects of mergers on labor markets; (ii) we show that the labor market effects of mergers in our model economy align in sign and magnitude with recent empirical evidence in Arnold (2020); (iii) we simulate a representative set of mergers in the U.S. to evaluate the implications of blocking mergers based on various local payroll Herfindahl-Hirschman Index (HHI) thresholds; (iv) we then contribute our preferred measure for regulating mergers which we call the *Required Efficiency Gains* (REGs): the productivity gains required to offset the negative effects of mergers on worker surplus (defined as total wage payments to households), thus leaving workers unharmed; (v) we show how REGs relate to various measures of HHI levels and predicted changes; and (vi) we derive a *Gross Downward Wage Pressure Index* (GDWPI) and show how this also relates to our REG measures. These results can help form the basis of new horizontal merger guidelines for labor markets.

We start by adding multi-plant ownership to the framework in BHM and derive the effects of mergers on firm- and market-level outcomes, including wages and employment. Absent efficiency gains, our main proposition establishes that a merger between two plants in the same market depresses market-level wages and employment, and wages decline unambiguously at both plants. Our results extend the product market analysis of Nocke and Schutz (2018b) –

which relies on exogenously determined household income – to a nested-CES labor supply system with Cournot competition and endogenously determined household income.[1] The quantitative model features decreasing returns to scale, multiple inputs, and oligopsony in the labor market, thus contributing to existing product market merger guidelines derived under constant returns to scale in Nocke and Whinston (2022).

We then estimate our model in order to test its predictions against existing empirical analyses and derive merger guidelines. Our baseline model without mergers is identical to BHM. Thus we adopt their parameter estimates which are based on confidential Census data. We define local labor market based on industry (3-digit North American Industry Classification System, *hereafter* NAICS3) and Commuting Zone (CZ) following BHM. Importantly, our model allows workers to move between markets.

We assess the model's quantitative performance by comparing the model's post-merger predictions to the recent empirical findings in Arnold (2020). We apply the same empirical specifications of Arnold (2020) to our model simulated data, and find that the model does well at replicating quantitatively the effect of mergers on employment and wages. Mergers depress employment and wages, and more so in concentrated markets. The success of the model at generating observed patterns in the data provides out-of-sample credibility to our estimated model.

Given the structure of the *Horizontal Merger Guidelines* as applied to product markets — which require demonstration of efficiency gains in order to offset consumer surplus losses due to increased market power — our analysis focuses on the *Required Efficiency Gains* (REGs) to achieve *worker surplus neutrality*. We define a merger to be worker surplus neutral whenever the market-level wage index in which the merger occurs remains unchanged. This welfare metric parallels the consumer surplus neutrality metric used in the product market by the DOJ and FTC (Pittman, 2007).

Our first exercise demonstrates how our methods can be employed in merger review by simulating the *Penguin Random House* (PRH) and *Simon & Schuster* (SS) merger. First, in the absence of any efficiency gains, the PRH and SS merger reduces market-level author wages by 5 percent. Second, we compute a REG of 17 percent. This means that the productivity gains due to the consolidation of the two businesses would have to be at least 17 percent at both businesses to offset the negative market power effects of the merger and leave workers (authors) unharmed.

[1] To our knowledge, no articles derive predictions for mergers in the nested-CES, Cournot competition setting in either product or labor markets. Nocke and Schutz (2018b) and Nocke and Schutz (2018a) restrict their analysis to Bertrand competition in the product market; Nocke and Whinston (2022) consider a simple example with CES preferences and Cournot competition in the product market.

Our second exercise measures the effects of applying the 1982 and 2010 product market merger review guidelines to the labor market. These guidelines rely on Herfindahl-based review thresholds, including the post-merger level of the Herfindahl index and its merger-induced change, ΔHHI. The more stringent 1982 guidelines presume anticompetitive effects whenever post-merger HHIs exceed 1800 and ΔHHIs exceed 100. The less stringent 2010 guidelines presume anticompetitive effects whenever post-merger HHIs exceed 2500 and ΔHHIs exceed 200.

We apply these guidelines to a representative set of simulated mergers. By design, our simulation replicates key summary statistics of mergers based on U.S. Census data, as reported in Arnold (2020). Our simulated merger review process assumes that the government blocks mergers that are (i) in markets where the naive post-merger HHI exceeds the threshold specified by the guidelines (where *naive* means pre-merger market shares are used in the calculation)[2] and (ii) in markets where the naive post-merger change in HHI exceeds the threshold specified by the guidelines.

If we adhere to 1982 guidelines and block mergers that generate post-merger HHIs above 1800 and that raise the HHI by more than 100, we find that the average REG of permitted mergers is 4.68 percent. In other words, permitted mergers must generate an average productivity gain of 4.68 percent for workers to be as well off as they were before the merger. If we adhere to 2010 guidelines and block mergers that result in post-merger HHIs above 2500 and that raise the HHI by more than 200, the average REG of permitted mergers is 5.96 percent. This means that under the standard assumed efficiency gain of 5 percent (Farrell and Shapiro (2010)), permitted mergers yield worker surplus losses, and therefore workers are harmed. Thus, our simulations suggest that workers are, on average, worse off under the enforcement of the more lenient 2010 merger guidelines and better off under the enforcement of the more stringent 1982 merger guidelines. Therefore, if efficiency gains are assumed to be 5 percent and if the goal of the DOJ and FTC is to conserve resources by only reviewing those mergers most likely to harm workers while ensuring that workers are unharmed by permitted mergers, the 1982 guidelines of $(HHI = 1800, \Delta HHI = 100)$ achieve that goal, whereas the 2010 guidelines of $(HHI = 2500, \Delta HHI = 200)$ do not.

Why do labor markets require more stringent merger review guidelines than product markets to ensure workers are unharmed? Firm market power in our framework derives from how costly it is to induce workers to move within and across markets to accept a job. While we lack comparable economy-wide estimates of product substitutability outside of manufacturing (see

[2]Following the Horizontal Merger Guidelines DOJ and FTC (2010), we compute the change in the Herfindahl index based on pre-merger shares. For example, $\Delta HHI = (s_1 + s_2)^2 - s_1 - s_2$ where s_1 and s_2 are the pre-merger payroll shares of the merging firms.

Edmond, Midrigan, and Xu (2018)), it is arguably more costly for workers to change employers than switch products. Low labor supply elasticities imply significant wage markdowns and increases the likelihood of worker harm after a merger.[3]

Our third exercise focuses on the downward wage pressure generated by mergers. When firms merge, they internalize how their hiring patterns at existing plants raise labor costs at their newly acquired plants and vice versa. This leads to downward wage pressure that may, in theory, be offset by efficiency gains from the merger. We measure downward wage pressure using a Gross Downward Wage Pressure Index (GDWPI). We show that this can be expressed as a function of simple labor market metrics: the firm-level labor supply elasticity, market-level labor supply elasticity, and payroll shares of the merging firms. The GDWPI has a natural interpretation as the percent wage reduction caused by the merger.

Following an identical methodology to our second exercise, we simulate a representative set of mergers, and for each merger, we compute (i) the GDWPI induced by the merger at both plants and (ii) the REGs necessary to offset the induced downward wage pressure. As we discuss in Section 3 on institutional background, product market upwards price pressure (UPP) tests (e.g. Farrell and Shapiro, 2010) ask whether product prices would rise under the assumption of 5 percent (or often lower) efficiency gains. We find that among mergers with a GDWPI of more than five percent (at both plants), more than 80 percent of mergers have a REG of at least 5.8 percent. This means that an efficiency gain of *more than* five percent is necessary to prevent worker harm in the vast majority of mergers in which gross downward wage pressure exceeds five percent.

The results we present in this paper allow researchers and regulators to compare the probability of a merger generating a worker surplus loss under different cut-offs for merger review based on local payroll Herfindahls, merger-induced Herfindahl changes, and downward wage pressure. For a given level of "Type I" error tolerance—i.e. reviewing mergers that would increase worker surplus—our results allow a regulator to formulate a locus of cut-offs for merger efficiency gains and concentration statistics. For example, a regulator that is less risk-averse or resource-poor would want to review few mergers. Given an assumed efficiency gain, the regulator may choose a concentration threshold for merger review above which it expects only 20 percent of mergers to yield worker surplus gains. A more risk-averse or resource-rich regulator would want to review many mergers and hence set lower concentration cut-offs for merger review. Our results can be used to compute such thresholds.

Just as previous product market assessments of mergers treated wage setting and hiring be-

[3]The estimates of labor supply elasticities in Berger, Herkenhoff, and Mongey (2022) reflect this low degree of substitutability and yield payroll weighted markdowns of 22 percent for the U.S. economy, with significant variation across firms.

havior as "out of market" effects (e.g. Hemphill and Rose, 2018), our analysis treats product market outcomes as "out of market". Our results can be applied as an initial screen of any merger in which basic information on local labor market payroll and employment is known. If there are additional gains and losses occurring through changes in the quantities and prices of goods, those gains and losses must be factored into the subsequent analysis. This brings up an important conceptual issue. In a holistic merger review, many of the claimed efficiency gains from product market mergers may be the result of increased monopsony power and worker layoffs in the labor market. While outside the scope of the present paper, our framework can be modified to incorporate monopolistic pricing or richer theories of variable markups to address these issues (see Deb, Eeckhout, Patel, and Warren, 2022, for such a modification of our framework).

2 Relevant literature

Many studies address the welfare effects of mergers in the product market (e.g., see Williamson (1972), Farrell and Shapiro (1990) and Werden (1996) for notable early examples). More recently, advances have been made in richer 'aggregative game' settings (e.g. Nocke and Schutz, 2018a,b; Nocke and Whinston, 2022). These creative papers have derived the welfare and comparative static implications of mergers in settings with firm price (Bertrand) competition. Our primary contribution to this theoretic literature is to derive comparative statics of mergers in models of oligopsony and quantity (Cournot) competition. The assumption of Cournot competition allows us to derive simple post-merger markdowns and then characterize the effects of mergers on outcomes at the market and firm levels. While much of our analysis shares common results with the product market (Nocke and Schutz, 2018a), the use of nested-CES labor supply and Cournot competition makes our theoretical results unique, and the use of decreasing returns to scale in production makes them quantitatively relevant.

Recent research by Naidu, Posner, and Weyl (2018) and Marinescu and Hovenkamp (2019) offers an overview of monopsony and antitrust issues. Marinescu and Hovenkamp (2019) provide a careful and insightful translation of product market antitrust concepts to the labor market. Naidu, Posner, and Weyl (2018) explore *Downward Wage Pressure* tests, but do not provide specific guidance on calculating the inputs to the tests. Their main example focuses on the simpler case of symmetric firms, where all firms have the same productivity level. However, market power typically arises from productivity asymmetry (i.e., some firms are larger than others), and mergers tend to be between larger firms. Our contributions are: (i) developing a downward wage pressure test within a framework of oligopsony that accounts for heterogeneity in firms across and within markets, and (ii) demonstrating that the degree of downward wage pressure can be calculated using easily obtainable labor market statistics and parameters for which existing estimates are available.

Related to our Herfindahl thresholds in the labor market, Nocke and Whinston (2022) provides a theoretical assessment of Herfindahl thresholds in the product market. They argue that when evaluating *unilateral effects*—where unilateral effects *"enhance market power simply by eliminating competition between merging parties"* (see DOJ and FTC, 2010)—only the merging firms' market shares are relevant. This result is specific to the preferences and forms of competition considered in Nocke and Whinston (2022) and does not necessarily extend to models in which there is disutility from hours worked, such as the present paper, or in richer models with coordinated effects (i.e., the scope for tacit collusion, etc.).[4] We contribute to this literature along several dimensions by (1) considering the labor market and using nested-CES labor supply to flexibly capture worker substitutability across local labor markets, (2) incorporating decreasing returns to scale (or isomorphically monopolistic competition in the product market), (3) providing analysis of downward wage pressure, and (4) quantitatively assessing the efficiency gains necessary to avoid losses in worker surplus, output, and employment at both the firm and market level. These contributions, along with our focus on the labor market, distinguish our work from Nocke and Schutz (2018a), Nocke and Schutz (2018b), and Nocke and Whinston (2022).

Another large empirical literature attempts to measure the efficiency gains of mergers (e.g., see early work by Maksimovic and Phillips (2001) and recent work by Blonigen and Pierce (2016) and Malmendier, Moretti, and Peters (2018)). Early contributions on the impact of mergers on employment at the *firm level* include Conyon, Girma, Thompson, and Wright (2002) and Gugler and Yurtoglu (2004).[5] However, there is much less research on mergers and employment at the market level. Very recent work by Arnold (2020) and Prager and Schmitt (2021) provide evidence for post-merger local labor market outcomes in the U.S. Arnold (2020) considers the effects of mergers on wages and employment across all industries in the U.S. He finds employment and wage losses are more severe in local labor markets in which the merger induces a greater change in concentration. We directly benchmark our model to his findings, replicating his regressions in mergers that satisfy the same properties as his sample. Prager and Schmitt (2021) considers the impact of employer consolidation on wages in the hospital industry. Using

[4] Unilateral effects are distinct from *Coordinated effects* which *"diminish competition by enabling or encouraging post-merger coordinated interaction among firms in the relevant market that harms customers."*, see DOJ and FTC (2010).

[5] Gugler and Yurtoglu (2004) summarizes well the early literature on the employment effects of mergers. More recent work by Ouimet and Zarutskie (2016) and Geurts and Van Biesebroeck (2017) examine the employment effects of mergers using propensity score matching techniques. Work on private equity by Davis, Haltiwanger, Handley, Jarmin, Lerner, and Miranda (2014) and Olsson and Tåg (2017) also show how changes in firm structure (negatively) affect employment and wages. Goldschmidt and Schmieder (2017) studies the opposite phenomenon of outsourcing; however, he finds wages losses among outsourced workers.

data on hospital mergers between 2000 and 2010 in the United States, they estimate a significant reduction in wages for skilled healthcare workers. Negative wage effects are larger in markets with higher initial concentration but also lower unionization rates, suggesting market power and labor market institutions play important roles in shaping the impact of employer consolidation on wages.

Lastly, Holmes and Schmitz Jr (2010), Schmitz Jr (2020) and Blonigen and Pierce (2016) review evidence on the efficiency gains resulting from competition and mergers, respectively. Blonigen and Pierce (2016) finds that mergers generate zero productivity gains (and in many specifications productivity losses) in a variety of specifications in the U.S. manufacturing industry, while other specific case studies have found larger positive gains on the order of 2 percent, e.g., Ashenfelter, Hosken, and Weinberg (2015) and Bonnet and Schain (2020). While their focus is not on mergers *per se*, Holmes and Schmitz Jr (2010) argue that increases in competition go hand-in-hand with increases in efficiency. Schmitz Jr (2020) provides a variety of additional examples where less competition reduces productivity in several major sectors including housing and construction.

3 Institutional background: Conduct of merger review, and the Penguin Random House case

We first describe the institutional setting governing antitrust enforcement and merger review guidelines in the United States as laid out by the Department of Justice (DOJ) and Federal Trade Commission (FTC) *"Horizontal Merger Guidelines"* (DOJ and FTC, 2010). We then discuss how the anticompetitive effects of monopsony were assessed and litigated when Penguin Random House attempted to purchase Simon & Schuster. At each step, we describe where our analysis can be used to inform policy.

Merger review. As stated in the Horizontal Merger Guidelines, the DOJ and FTC are primarily concerned with whether a merger generates consumer surplus losses.[6] Under the *Hart–Scott–Rodino Antitrust Improvements Act of 1976*, a merger in which one of the parties has annual sales or total assets above $151 million (among other criteria) must be notified to the DOJ and FTC ahead of its consummation. The DOJ and FTC may challenge the merger if they determine that it may *"substantially lessen competition"* under Section 7 of the *Clayton Antitrust Act of 1914*.[7] However, the law also requires recognition of harm to input suppliers, including workers.

To measure the effects of a merger on consumers, the DOJ and FTC must define a market.

[6] *"Regardless of how enhanced market power likely would be manifested, the Agencies normally evaluate mergers based on their impact on customers."* (DOJ and FTC, 2010, p. 2).

[7] See documentation provided by the FTC: https://www.ftc.gov/enforcement/merger-review

In the product market, a *Hypothetical Monopolist Test* is applied to define the boundary of a market. This test conjectures a market boundary—e.g., diet cola products—and asks whether a hypothetical monopolist, unbound by price regulation and supplying that entire market, would impose a small but significant and non-transitory increase in price (a 'SSNIP') on at least one product in the market. If the answer is 'no' because a close substitute exists—e.g., non-diet cola products—then the conjectured market boundary is expanded until the answer is 'yes' (DOJ and FTC, 2010, p. 9). The SSNIP cutoff is often taken to be 5 percent by the DOJ and FTC (DOJ and FTC, 2010, p. 10). We will impose a market definition in our model but find that our estimated substitutability of labor across markets is consistent with such a test. From the perspective of workers, local labor markets are not close substitutes, and hence a hypothetical monopsonist would engage in a small but significant and non-transitory decrease in wages.

Product market tests used by the DOJ and FTC also factor in targeted subsets of consumers as separate markets. If the hypothetical monopolist can "profitably target a subset of customers for price increases," then the DOJ and FTC may define a market around those individuals (DOJ and FTC, 2010, p. 12). This is particularly relevant in the labor market setting that follows.

The DOJ and FTC then screen mergers for deeper review based on measures of market concentration, including the Herfindahl-Hirschman Index (HHI) and merger-induced changes in the HHI, which may now be computed given the market definition.[8] The 2010 Horizontal Merger Guidelines lay out three categories of market concentration. First, *"Mergers involving an increase in the HHI of fewer than 100 points are unlikely to have adverse competitive effects and ordinarily require no further analysis"* (DOJ and FTC, 2010, p. 19). For moderately concentrated markets with Herfindahls above 1500, they write *"Mergers resulting in moderately concentrated markets that involve an increase in the HHI of more than 100 points potentially raise significant competitive concerns and often warrant scrutiny"* (DOJ and FTC, 2010, p. 19). Finally, for highly concentrated markets with Herfindahls above 2500, they write *"Mergers resulting in highly concentrated markets that involve an increase in the HHI of between 100 points and 200 points potentially raise significant competitive concerns and often warrant scrutiny"* (DOJ and FTC, 2010, p. 19).

Our results in Section 4.5 are designed to aid in the formulation of these institutional guidelines for merger review. We are unaware of any existing analysis that theoretically or quantitatively assesses the applicability of existing product market merger review criteria to the labor market. Our results and tables provide the first attempt at providing worker surplus metrics that can be used to evaluate various Herfindahl-based thresholds in the labor market.

[8] The Herfindahl-Hirschman Index (HHI) is the sum of the market participants' share of sales squared. Shares are measured in percent, hence $HHI \in [0, 10000]$. For example, a market with two firms with sales each accounting for 50 percent of total sales has an HHI of $50^2 + 50^2 = 5000$. In some settings the shares are defined over quantities sold.

The Horizontal Merger Guidelines also provide other routes to merger review. First, agencies may calculate the unilateral effects of mergers when markets cannot be adequately defined because products are highly differentiated. Second, when sufficient data are available, agencies may calculate the impact of a merger on the prices of different products sold by the merging entities by determining diversion ratios of those products and the margins of those products. Third, agencies may use merger simulation methods (DOJ and FTC, 2010, Section 6.1). Our results in Section 9 provide a similar "downward wage pressure" method for calculating the impact of a merger on a labor market characterized by highly differentiated occupations.

Penguin Random House case. We discuss these tests in the context of the *Penguin Random House* case, henceforth the PRH case. PRH and Simon & Schuster (SS) were the first and third largest among the *'Big Five'* commercial publishers in the United States. In an unusual twist, the government did not challenge the merger on the basis of its impact on the price of books. Instead, the government focused on the merger's impact on compensation for authors (i.e., advances and royalties). The government argued that the proposed merger would substantially lessen competition via increased buyer market power in the *anticipated top-selling book* market. This market was defined as books receiving an advance of at least $250,000.

A major issue in the case was market definition. The defendants argued the market should include publishers of all books, including small publishers outside the Big Five and self-publishing. The government prevailed as it established that a hypothetical monopsonist controlling the *anticipated top-selling book* publishing market could lower author wages by a small but significant amount without authors moving to small publishers or self-publishing. In this market, (i) the two firms had a combined pre-merger market share of 49 percent, (ii) the post-merger HHI would be above $3,111$, resulting in a highly concentrated market, and (iii) the merger would induce an increase in the HHI of 891. Based on these criteria, the government met its burden to establish the prima facie case of anticompetitive effects from the merger.

In the rebuttal and subsequent discussion, a number of models and tests were adapted to the monopsony setting and applied to the case (Pan, 2021, p. 56). These included Gross Upward Pricing Pressure Index (GUPPI) tests. In particular, the government's expert pointed out that PRH and SS frequently competed for manuscripts in the last round of auctions held by authors' agents. Using diversion ratios calculated from the data as well as other inputs in various auction models, the expert estimated the merger would reduce compensation by 3.7 to 7.4 percent for authors of books published by PRH and by 6.4 to 19.2 percent for authors of books published by SS.

Our analysis yields outputs that are directly applicable in such cases. First, our downward wage pressure formulas derived in Section 9 parallel the tests employed in the PRH case. We show how the structure of our model yields closed form expressions for downward wage pressure in terms of market shares, employment, and estimates of the substitutability of workers within and across markets. Second, Section 8 provides the first quantitative analysis of Herfindahl-based thresholds and estimates of worker surplus losses as a function of various labor market concentration metrics. This is important since the prima facie case relied on horizontal merger guidelines for the product market.

Overview. The remainder of the paper proceeds as follows. We develop our theoretical framework in Section 4, including a proposition that establishes comparative statics for employment and wages following a merger. In Section 5, we calibrate the model, and in Section 6, we show that the model replicates observed post-merger paths for employment and wages as documented by Arnold (2020). We begin our policy analysis in Section 7 by applying the model to study the PRH SS merger case. In Section 8, we then assess Labor Market Merger Guidelines by simulating a representative set of mergers and computing (i) the labor market effects of various merger review thresholds as well as (ii) the efficiency gains necessary to mitigate worker surplus losses, output losses, and employment losses. Lastly, Section 9 provides formulas for the downward wage pressure caused by mergers and the necessary efficiency gains to offset the worker surplus losses stemming from the downward wage pressure.

4 Model

We now describe a simplified model economy where firms produce using a labor-only, constant returns to scale production function. We start here because it allows us to provide an analytical characterization of the equilibrium market-level and firm-level responses to a merger. In Section 4.5, we extend the model to include capital and decreasing returns to scale as in BHM. The extended model is used in our quantitative exercises.

4.1 Environment

Agents. There is a representative household and a continuum of firms divided across a unit measure of markets indexed by $j \in [0,1]$. Within each market, there is an exogenously given finite number of firms M_j indexed by $i \in \{0, \ldots, M_j\}$. The only *ex-ante* difference between markets is the number of firms, M_j. Time is discrete and runs forever, and the representative household discounts the future at rate $\beta \in (0,1)$.

Goods and technology. Final goods are perfect substitutes and are used as the numeraire. Firms are heterogeneous in their productivity $z_{ij} \in (0, \infty)$, which are drawn from a location-invariant distribution $F(z)$. A firm hires labor n_{ij} to produce output y_{ij} according to the production function:

$$y_{ij} = z_{ij} n_{ij}.$$

4.2 Household

Preferences and problem. Every period, a representative household chooses the amount of labor to supply to each firm, n_{ij}, and how much of each firm's good to consume, c_{ij}, in order to maximize their flow utility, $U(\cdot)$, subject to their budget constraint. Their problem is

$$\max_{\{n_{ij}, c_{ij}\}} \; U\Big(\mathbf{C}, \mathbf{N}\Big) \tag{1}$$

where the aggregate employment index, $\mathbf{N}$, is given by,

$$\mathbf{N} := \left[\int_0^1 \mathbf{N}_j^{\frac{\theta+1}{\theta}} \, dj\right]^{\frac{\theta}{\theta+1}} \quad , \quad \mathbf{N}_j := \left[n_{1j}^{\frac{\eta+1}{\eta}} + \cdots + n_{M_j j}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}} \quad , \quad \eta > \theta > 0$$

the aggregate consumption index is given by,

$$\mathbf{C} := \int_0^1 \Big[c_{1j} + \cdots + c_{M_j j}\Big] \, dj,$$

and maximization is subject to the household's budget constraint:

$$\mathbf{C} \;\; = \;\; \int_0^1 \Big[w_{1j} n_{1j} + \cdots + w_{M_j j} n_{M_j j}\Big] \, dj + \Pi. \tag{2}$$

The budget constraint implicitly assumes that firm profits, Π, are rebated lump sum to the household.

In terms of notation, we bold all indexes which are not directly observable in data but can be constructed from observables and estimates of parameters. For example, the market-level labor supply index to market j, $\mathbf{N}_j$, is not observed. However, with data on firm level employment, n_{ij}, and an estimate of η, we can measure $\mathbf{N}_j$.

Labor supply. Given wages, $\{w_{ij}\}$, household optimality conditions yield the following firm-specific, upward-sloping labor supply curves:

$$n_{ij} = \left(\frac{w_{ij}}{\mathbf{W}_j}\right)^{\eta} \left(\frac{\mathbf{W}_j}{\mathbf{W}}\right)^{\theta} \mathbf{N} \quad , \quad \text{for all} \quad i = 1, \ldots, M_j \, , \, j \in [0,1], \tag{3}$$

where we implicitly define the *market wage index* $\mathbf{W}_j$ and *aggregate wage index* $\mathbf{W}$ so that

$$\mathbf{W}_j\mathbf{N}_j := \sum_{i\in j} w_{ij}n_{ij} \quad , \quad \mathbf{W}\mathbf{N} := \int_0^1 \mathbf{W}_j\mathbf{N}_j \, dj.$$

Together with (3), these definitions imply constant elasticity of substitution wage indexes:

$$\mathbf{W}_j = \left[\sum_{i\in j} w_{ij}^{1+\eta}\right]^{\frac{1}{1+\eta}} \quad , \quad \mathbf{W} = \left[\int_0^1 \mathbf{W}_j^{1+\theta} dj\right]^{\frac{1}{1+\theta}}. \tag{4}$$

Equivalently, we can express the inverse labor supply function as follows:

$$w_{ij} = \left(\frac{n_{ij}}{\mathbf{N}_j}\right)^{\frac{1}{\eta}} \left(\frac{\mathbf{N}_j}{\mathbf{N}}\right)^{\frac{1}{\theta}} \mathbf{W}. \tag{5}$$

Elasticities. Parameters η and θ govern the elasticity of substitution within markets and across markets, respectively. They jointly determine firm market power.[9] As $\eta \to \infty$, workers are willing to perfectly substitute across firms within a market. Greater substitutability erodes firms' market power. The same is true as $\theta \to \infty$ as workers are willing to perfectly substitute across markets, and this erodes firm market power. Intuitively, θ represents mobility costs across markets, which are often estimated to be significant (Kennan and Walker, 2011) while η stands in for within-market, across-firm mobility costs such as commute costs or differences in non-wage amenities.

Note the following relationship to a *Hypothetical Monopolist Test*. A hypothetical monopsonist that controls employment at all firms in the market, would face an elasticity of labor supply of θ, since it only competes across markets. If markets are defined too narrowly, then the hypothetical monopsonist would face close substitutes outside the market and have no incentive to lower wages. In other words, if we define markets too narrowly, then we would infer a θ that is large, indicating close substitutes outside the market. Hence the market definition should be expanded until the implied θ is lower. When we later define markets as a commuting zone and industry pair, we will estimate a low θ, and so conclude that our market definition is consistent with a hypothetical monopsonist test.

[9] BHM apply results from Anderson, De Palma, and Thisse (1987) and Verboven (1996) to micro found these preferences from a discrete choice model.

4.3 Firms

Firm granularity is a necessary ingredient in studying mergers. In our economy, firms are small with respect to the aggregate economy, and so they take the aggregate wage $\mathbf{W}$ and labor supply $\mathbf{N}$ as given. However, they are large within a market, and thus they internalize their effects on market-level employment, $\mathbf{N}_j$, and market-level wages, $\mathbf{W}_j$. Our baseline calibration assumes Cournot competition, but we also provide the relevant formulas for Bertrand competition. Under Cournot competition, firms solve the following problem:

$$\pi_{ij} = \max_{n_{ij}} \; z_{ij}n_{ij} - w_{ij}n_{ij}.$$

subject to the labor supply curve (5). Expanding the terms in equation (5), the firm understands that they influence all terms in *blue* in the labor supply system:

$$w_{ij} = n_{ij}^{\frac{1}{\eta}} \left(n_{1j}^{\frac{\eta+1}{\eta}} + \cdots + n_{ij}^{\frac{\eta+1}{\eta}} + \cdots + n_{M_j j}^{\frac{\eta+1}{\eta}} \right)^{\frac{\eta}{\eta+1}\left[\frac{1}{\theta}-\frac{1}{\eta}\right]} \mathbf{N}^{-\frac{1}{\theta}}\mathbf{W}$$

Taking first order conditions and rearranging, we can express the firm's optimal wage as a *markdown* (μ_{ij}) on the marginal revenue product of labor, z_{ij},

$$w_{ij} = \mu_{ij}z_{ij} \quad , \quad \mu_{ij} \in (0,1), \tag{6}$$

where the markdown is a function of the firm's payroll share of market j, s_{ij}, and is given by[10]

$$\mu(s_{ij}) = \frac{\varepsilon(s_{ij})}{\varepsilon(s_{ij})+1} \quad , \quad s_{ij} = \frac{w_{ij}n_{ij}}{\sum_{i=1}^{M_j} w_{ij}n_{ij}} \quad , \quad \varepsilon(s_{ijt}) = \left[s_{ijt}\frac{1}{\theta} + (1-s_{ijt})\frac{1}{\eta} \right]^{-1}. \tag{7}$$

[10]This derivation follows immediately from the first order conditions and the following expressions for payroll shares. Substituting the inverse labor supply curve into the definition of the payroll shares yields

$$s_{ij} = \frac{w_{ij}n_{ij}}{\sum_{i=1}^{M_j} w_{ij}n_{ij}} = \frac{\left(\frac{n_{ij}}{\mathbf{N}_j}\right)^{\frac{1}{\eta}} \left(\frac{\mathbf{N}_j}{\mathbf{N}}\right)^{\frac{1}{\theta}} \mathbf{W}n_{ij}}{\sum_{i=1}^{M_j} \left(\frac{n_{ij}}{\mathbf{N}_j}\right)^{\frac{1}{\eta}} \left(\frac{\mathbf{N}_j}{\mathbf{N}}\right)^{\frac{1}{\theta}} \mathbf{W}n_{ij}} = \left(\frac{n_{ij}}{\mathbf{N}_j}\right)^{\frac{1+\eta}{\eta}} = \frac{\partial \mathbf{N}_j}{\partial n_{ij}} \frac{n_{ij}}{\mathbf{N}_j}.$$

Likewise, substituting the labor supply curve into the definition of the payroll share yields $s_{ij} = \left(\frac{w_{ij}}{\mathbf{W}_j}\right)^{1+\eta} = \frac{\partial \mathbf{W}_j}{\partial w_{ij}} \frac{w_{ij}}{\mathbf{W}_j}$.

Hence, this framework yields variable markdowns. Firms with greater payroll shares in the market (high s_{ij}) pay workers a smaller fraction of the marginal revenue product (lower μ_{ij}). For very large firms within a market, $s_{ij} = 1$, the markdown is given by $\mu(1) = \frac{\theta}{\theta+1}$, whereas for very small firms within a market, $s_{ij} = 0$, the markdown is given by $\mu(0) = \frac{\eta}{\eta+1} > \frac{\theta}{\theta+1} = \mu(1)$. Under Bertrand competition, a similar wage equation is obtained in which the only difference is in the formula for the labor supply elasticity:

$$\varepsilon^{Bertrand}(s_{ijt}) = s_{ijt}\theta + (1 - s_{ijt})\eta. \tag{8}$$

Equilibrium. An equilibrium in this economy is an economy-wide vector of wage-bill shares, $\mathbf{s} = \{\mathbf{s}_j\}$ where $\mathbf{s}_j = (s_{1j}, \ldots, s_{M_j j})$, such that wages and employment are consistent with the vector of wage-bill shares. In equilibrium, firms take their competitors' choices as given and choose their best responses.

4.4 Mergers

Next, we define what we mean by a merger between two firms i and i' in market j. We then derive key analytical properties of merging firms' wages and employment.

First, from the perspective of a household, preferences are unchanged following a merger. That is, the household has the same aggregator over employment at all locations M_j within market j, and will face different wages at all locations. Second, from the merging firm's perspective, following a merger, the single merged firm chooses employment at both locations (or plants) i and i' to maximize *joint* profits, internalizing any spillovers between the two newly merged plants. Under Cournot competition, the objective of the combined firm is:

$$\pi_{ij} = \max_{n_{ij}, n_{i'j}} \; z_{ij}n_{ij} - w_{ij}n_{ij} + z_{i'j}n_{i'j} - w_{i'j}n_{i'j},$$

subject to the labor supply curves for both i and i', given by (5). Expanding the terms in equation (5) for i and i', the newly merged firm understands that they influence all labor supply terms in *blue*, including the cross-plant impact of their hiring decisions:

$$w_{ij} = {\color{blue}n_{ij}}^{\frac{1}{\eta}} \left(n_{1j}^{\frac{\eta+1}{\eta}} + \cdots + {\color{blue}n_{ij}}^{\frac{\eta+1}{\eta}} + \cdots + {\color{blue}n_{i'j}}^{\frac{\eta+1}{\eta}} + \cdots + n_{M_j j}^{\frac{\eta+1}{\eta}} \right)^{\frac{\eta}{\eta+1}\left[\frac{1}{\theta} - \frac{1}{\eta}\right]} \mathbf{N}^{-\frac{1}{\theta}} \mathbf{W}$$

$$w_{i'j} = {\color{blue}n_{i'j}}^{\frac{1}{\eta}} \left(n_{1j}^{\frac{\eta+1}{\eta}} + \cdots + {\color{blue}n_{ij}}^{\frac{\eta+1}{\eta}} + \cdots + {\color{blue}n_{i'j}}^{\frac{\eta+1}{\eta}} + \cdots + n_{M_j j}^{\frac{\eta+1}{\eta}} \right)^{\frac{\eta}{\eta+1}\left[\frac{1}{\theta} - \frac{1}{\eta}\right]} \mathbf{N}^{-\frac{1}{\theta}} \mathbf{W}$$

Markdowns of the merged firm. Without loss of generality, assume $i = 1$ and $i' = 2$. Under Cournot competition, the first order condition for n_{1j} equates the *net marginal benefit* of hiring (left-hand side) to the *marginal cost* of hiring (right-hand side), which includes the wage plus the increase in the wage to all inframarginal workers:

$$z_{1j} - \underbrace{\frac{\partial w_{2j}}{\partial n_{1j}} n_{2j}}_{:=\text{Downward wage pressure}} = \frac{\partial w_{1j}}{\partial n_{1j}} n_{1j} + w_{1j}. \tag{9}$$

The newly-merged firm internalizes that when they hire at Plant 1, the wage at Plant 2 increases. Hiring more at Plant 1 requires a higher wage; this tightens competition in the labor market, requiring a higher wage at Plant 2 in order to maintain the same size.

Hence there is an additional, positive term that governs the *downward wage pressure* caused by a merger. This term can be read as a marginal cost that has to be subtracted from the usual marginal benefit, i.e., productivity z_{1j}. With a lower net marginal benefit of hiring, the firm will hire fewer workers and hence pay lower wages. In Section 9, we define a gross downward wage pressure index (GDWPI) and derive a closed-form share-based formula for it.

One key result is that wages are determined by a common markdown based on the combined shares of the newly merged plants. This mirrors the result in Nocke and Schutz (2018b) who consider Bertrand competition in the product markets with exogenously given income. Rearranging equation (9), we find that the markdown for both of the merged firms is as in equation (7), but where the argument of $\mu(\cdot)$ is now the post-merger combined share $(s_{1j} + s_{2j})$:[11]

$$w_{1j} = \mu\left(s_{1j} + s_{2j}\right) z_{1j} \quad , \quad w_{2j} = \mu\left(s_{1j} + s_{2j}\right) z_{2j}$$

Therefore we have the following characterization of post-merger markdowns, where primes denote post-merger outcomes (i.e., μ'_{1j} and μ'_{2j} are post-merger markdowns):

$$\mu'_{1j} = \mu'_{2j} = \mu\left(s'_{1j} + s'_{2j}\right)$$

Note that the above algebra generalizes in an analogous way to the case of an arbitrary set of

[11] Using this expression and the property that $\frac{\partial \mathbf{N}_j}{\partial n_{ij}} \frac{n_{ij}}{\mathbf{N}_j} = s_{ij}$ allows one to simplify the first order condition of the firm:

$$mrpl_{1j} - w_{1j} = \left(\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) s_{1j}\right) w_{1j} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) s_{1j} \frac{w_{2j} n_{2j}}{n_{1j}}$$

$$mrpl_{1j} - w_{1j} = \left[\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right)\left(s_{1j} + s_{2j}\right)\right] w_{1j}$$

merging firms.[12] Using this insight, we establish the following analytical results:

Proposition 1. *In the Cournot model outlined in Section 4, if firms $i = 1$ and $i' = 2$ merge, the following are true:*

1.1 *Following a merger, the markdowns at the merged plants are equalized and depend on the total market share, $\mu'_{1j} = \mu'_{2j} = \mu\left(s'_{1j} + s'_{2j}\right)$.*

1.2 *Under either monopsony limit (i.e., infinitely many firms in each market, or $\eta = \theta$), firms are atomistic, and hence a merger has no effect on any labor market variables.*

1.3 *The individual shares s_{kj} of all non-merging firms increase: $s'_{kj} > s_{kj}$ for all $k \notin \{1, 2\}$. Hence their markdowns widen, and their wages fall: $w'_{kj} < w_{kj}$. The combined market share of merging firms falls: $s'_{1j} + s'_{2j} < s_{1j} + s_{2j}$.*

1.4 *The wage index of non-merging firms <u>decreases</u> and employment index <u>increases</u>.*

1.5 *Indexes for the market wage $\mathbf{W}_j$ and employment $\mathbf{N}_j$ decline, hence total market pay $\mathbf{W}_j\mathbf{N}_j = \sum_{i\in j} w_{ij}n_{ij}$ declines.*

1.6 *The wages of both merging firms decline: $w'_{ij} < w_{ij}$ for $i \in \{1, 2\}$. The wage index of merging firms <u>decreases</u> and employment index <u>decreases</u>. At least one of the merging firms' employment decreases.*

Proof. See Appendix A.

Proposition 1.2 states that if firms are infinitesimal—either because (i) there are infinitely many firms in each market, or (ii) because preferences are such that households find firms equally substitutable between and within markets—and hence all firms compete against infinitely many firms in a national market, then mergers have no effect on the labor market.[13] In both cases, firms would set wages equal to a markdown $\mu(0) = \eta/(\eta+1)$ at both plants. Wages are unchanged, and hence employment allocations are unchanged.

The remaining propositions show that in the presence of oligopsony, the negative effect of a merger ripples throughout the market, leading even non-merging firms to reduce their

[12] Let the set of merging firms be A, then

$$\mu'_{ij} = \mu\left(\boldsymbol{s}'_{jA}\right) \quad \boldsymbol{s}'_{jA} = \sum_{i\in A} s'_{ij}. \tag{10}$$

[13] Note again the relationship to the hypothetical monopolist test. If $\eta = \theta$, then for any definition of the labor market which is less than the entire economy, a hypothetical monopsonist would *not* cut wages since they must compete aggressively across markets. The hypothetical market would have to be increased and increased until it equals the entire economy, and hence the market includes all firms, among which a single firm is atomistic.

wages. A key step in the proof is showing that the post-merger combined share of the merging firms is larger than either firms' initial share. With its new market power, the merged firm contracts total employment across its plant in order to pay lower wages. As it cuts its wages, its competitors are able to simultaneously cut their wages while also growing (Proposition 1.3, 1.4). With the merged entities shrinking, competitors obtain slightly more market power. Hence a merger causes *all firms* to reduce their wages, not only the merging firms. Despite all firms' wages declining, the change in relative wages tilts employment toward the non-merging firms, which expand (Proposition 1.4). With all firms' wages declining, the market wage falls, so market employment falls, and necessarily total pay to workers falls (Proposition 1.5).

An important, testable implication of Proposition 1 is that a *naive* prediction of the change in concentration will be inaccurate. By a naive prediction, we mean simply adding the pre-merger shares of the merging firms and computing concentration using this along with non-merging firms' pre-merger shares. Following a merger, Proposition 1.3 implies that concentration goes up by *less than implied* by the naive computation. The combined share of the merging firms shrinks precisely because they accrue more market power and cut back on employment. Meanwhile, the shares of the non-merging firms increase. As we will show below, this prediction of the model is borne out following mergers in US local labor markets.

Worker surplus neutrality. In order to make contact with existing merger review guidelines based on consumer surplus neutrality (e.g. see Werden, 1996; Pittman, 2007; Farrell and Shapiro, 2010; Nocke and Whinston, 2022), we propose a simple definition of worker surplus neutrality. To mirror the product market definition of consumer surplus neutrality, the definition is based on the household's problem in which profits are *not* rebated back to households.[14]

Definition - Worker Surplus Neutrality: *Let $\mathbf{W}_j$ denote the pre-merger wage index and let $\mathbf{W}'_j$ denote the post-merger wage index. A merger is <u>Worker Surplus Neutral</u> if $\mathbf{W}_j = \mathbf{W}'_j$ in all markets $j \in [0, 1]$.*[15]

In other words, the merger does not change remuneration to workers. The market level labor supply curve also implies that the household's disutility of labor supply is also unchanged. Thus mergers that are worker surplus neutral leave workers unharmed.

We will refer to cases in which the post-merger market-level wage index is greater than its pre-merger value as cases in which there is a worker surplus gain. Likewise, if there is a decline

[14]The household problem is to maximize utility given by equation (1) subject to the household's budget constraint, ex-profits: $\mathbf{C} = \int_0^1 \left[w_{1j}n_{1j} + \cdots + w_{M_j j}n_{M_j j} \right] dj$.

[15]The condition $\mathbf{W}_j = \mathbf{W}'_j$ in all markets j ensures that the merger does not affect $\mathbf{C}$, N, and W even when measures of firms merge. To this, note that if $\mathbf{W}_j = \mathbf{W}'_j$, then the market-level labor supply curve implies $\mathbf{N}_j$ is unchanged.

in the post-merger market-level wage index, we will refer to that as a worker surplus loss or worker harm.

This definition gives rise to the central focus of our analysis in the next quantitative section. In a series of simulated mergers, we compute the *Required Efficiency Gain*, denoted Δ^* henceforth, for worker surplus neutrality in every merger.

Definition - Required Efficiency Gains: *The Required Efficiency Gain (REG), denoted Δ^*, is the post-merger common efficiency gain across merging firms required such that the merger is worker surplus neutral.*

The required efficiency gains are common to both plants post-merger. To compute the required efficiency gain for worker surplus neutrality, we assume that the merged firm solves the following problem subject to the labor supply curves for both i and i' (given by equation (5)):

$$\pi_{ij} = \max_{n_{ij}, n_{i'j}} \; z_{ij} e^{\Delta^*} n_{ij} - w_{ij} n_{ij} + z_{i'j} e^{\Delta^*} n_{i'j} - w_{i'j} n_{i'j}, \tag{11}$$

where Δ^* is the value of the post-merger productivity gain that delivers worker surplus neutrality, and hence a constant market-level wage index $\mathbf{W}_j = \mathbf{W}'_j$. Note that an immediate implication of Proposition 1.5 is that the REG is always positive.

4.5 Quantitative model

Before turning to the data, we briefly describe how to extend the model to incorporate decreasing returns to scale, physical capital in production, and capital ownership as in previous work (see Berger, Herkenhoff, and Mongey, 2022).

Quantitative household problem. The household problem now incorporates capital ownership K_t, yielding forward-looking Euler equations. Capital depreciates at rate δ and is rented out at rate R_t. Households discount the future at rate β. As before, firm profits, Π_t, are rebated lump sum to the household. The household problem becomes,

$$\mathcal{U}_0 = \max_{\left\{n_{ijt}, c_{ijt}, K_{t+1}\right\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U\Big(\boldsymbol{C}_t, \boldsymbol{N}_t\Big) \tag{12}$$

subject to the household's budget constraint,

$$\boldsymbol{C}_t + \Big[K_{t+1} - (1-\delta)K_t\Big] \;\; = \;\; \int_0^1 \Big[w_{1jt} n_{1jt} + \cdots + w_{M_j jt} n_{M_j jt}\Big]\, dj + R_t K_t + \Pi_t. \tag{13}$$

where the aggregate consumption and labor supply indexes are defined the same as Section 4.

Quantitative firm problem. Let α denote the returns to scale, and γ denote the share parameter on labor. We also allow for an aggregate productivity shifter $\overline{Z}$. A firm now produces y_{ijt} units output according to the production function:

$$y_{ijt} = z_{ijt}\overline{Z}\left(k_{ijt}^{1-\gamma}n_{ijt}^{\gamma}\right)^{\alpha} \quad , \quad \gamma \in (0,1) \quad , \quad \alpha > 0.$$

Firms rent capital at rate R_t in a spot market, and they are price takers in the market for capital. It will be useful to substitute the firms' capital demand condition into its profits, yielding the following firm optimization problem:

$$\pi_{ijt} = \max_{n_{ijt}} \ \widetilde{z}_{ijt}n_{ijt}^{\widetilde{\alpha}} - w_{ijt}n_{ijt} \quad , \quad \text{subject to the inverse labor supply curve (3)},$$

where we introduce the auxiliary parameters $\{\widetilde{\alpha}, \widetilde{z}_{ijt}\}$:

$$\widetilde{\alpha} := \frac{\gamma\alpha}{1-(1-\gamma)\alpha} \quad , \quad \widetilde{z}_{ijt} := \left[1-(1-\gamma)\alpha\right]\left(\frac{(1-\gamma)\alpha}{R_t}\right)^{\frac{(1-\gamma)\alpha}{1-(1-\gamma)\alpha}}\left(z_{ijt}\overline{Z}\right)^{\frac{1}{1-(1-\gamma)\alpha}}.$$

5 Calibration

Our calibration follows directly from BHM, who calibrate an identical framework using U.S. Census data. Table 1 summarizes the model fit and the parameter values.

Additional elements of the economy are as follows. We assume that household preferences are of the GHH form:[16]

$$U(\mathbf{C}_t, \mathbf{N}_t) = \mathbf{C}_t - \overline{\varphi}^{-1/\varphi}\frac{\mathbf{N}_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}.$$

We define a market to be a 3-digit North American Industry Classification System (NAICS-3) code by commuting zone (CZ). Examples of adjacent NAICS-3 codes include *311 Food Manufacturing* and *312 Beverage and Tobacco Product Manufacturing*.

A key empirical feature of local labor markets is a large number of firms but concentrated employment among large firms. The distribution of firms-per-market, $M_j \sim G(M_j)$, is taken directly from the observed distribution of firms-per-market in the Longitudinal Business Database (LBD). On average, a market has 113 firms. Markets are concentrated, with an HHI of 0.11. This is the same HHI one would obtain from a market with approximately nine equally sized firms. We capture the heterogeneity in firm size within markets that delivers these statistics from the model.

Parameters θ and η are estimated based on tradeable firms' market-share-dependent responses to corporate tax changes. We refer readers to BHM for details on the natural exper-

[16]These are the baseline preferences in BHM. They also show that adding wealth effects involves a trivial change to $\overline{\varphi}$.

Parameter		Value	Moment	Model	Data
$G(m_j)$	Pareto and point mass at $m_j = 1$		Mean, Variance, Skewness of distribution 9 percent of markets have 1 firm		
θ	Across market substitutability	0.42	Held fixed at estimated tradeable value		
η	Within market substitutability	10.85	Held fixed at estimated tradeable value		
Estimated					
θ	Across market substitutability	0.42	Average $\widehat{\varepsilon}^{Data}(s)$ for $s \in [0.05, 0.10]$	1.49	1.43
η	Within market substitutability	10.85	Average $\widehat{\varepsilon}^{Data}(s)$ for $s \in [0, 0.05]$	1.53	1.61
σ_z	Productivity dispersion	0.312	Payroll weighted $\mathbb{E}[HHI_j]$	0.11	0.11
α	Decreasing returns to scale	0.940	Labor share	0.57	0.57
γ	Exponent on labor	0.808	Capital share	0.18	0.18
$\overline{Z}$	Productivity shifter	1.79×10^4	Mean firm size	22.8	22.8
$\overline{\varphi}$	Labor disutility shifter	3.099	Mean worker earnings ($000)	43.8	43.8

Table 1: Summary of Parameters

Notes: See BHM. $\widehat{\varepsilon}^{Data}(s)$ for $s \in [0.05, 0.10]$ is the reduced form labor supply elasticity (allowing for equilibrium responses of competitors) in response to a corporate tax shocks for firms with market shares between 5 percent and 10 percent. $\widehat{\varepsilon}^{Data}(s)$ for $s \in [0, 0.05]$ is the reduced form labor supply elasticity (allowing for equilibrium responses of competitors) in response to a corporate tax shocks for firms with market shares between 0 percent and 5 percent.

iment that informs η and θ. Our estimated values of η and θ imply markdowns such that $\mu(1) = \frac{\theta}{\theta+1} \approx 0.3$ for a firm in which $s_{ij} = 1$ and $\mu(0) = \frac{\eta}{\eta+1} \approx 0.91$ for a firm in which $s_{ij} = 0$. Since θ is low, a hypothetical monopsonist *would* seek to lower wages by a small but significant amount. Hence markets are defined appropriately through the lens of such a test. The average firm market share is around 0.02, implying the average firm pays close to competitive wages. However, large firms have more market power and more employment; the employment-weighted average markdown is 0.72, meaning the average worker is paid 72 percent of their marginal revenue product. This is equivalent to a representative household having a labor supply elasticity equal to 2.57.

Productivity is assumed to be distributed log normally, $\log(z_{ijt}) \sim N(1, \sigma_z^2)$. Productivity dispersion σ_z is estimated to match the payroll weighted Herfindahl, $\mathbb{E}[HHI_j]$.[17] When dispersion in productivity is higher, larger firms are larger and concentration increases. The degree of returns to scale, α, is estimated to match labor's share of income based on the Bureau of Economic Analysis. The exponent on labor, γ, is estimated to match the capital share (Barkai, 2020). The productivity shifter $\overline{Z}$ is chosen to exactly match the mean firm size in the LBD, and the labor disutility shifter $\overline{\varphi}$ is chosen to exactly match mean worker earnings.

[17]The aggregate Herfindahl is computed by summing the market-level payroll Herfindahls weighted by market-level payroll.

Moment	A. Arnold (2020)		B. Model
A. Targeted			
Median employment pre-merger	Table 1	116	116
B. Employment and wages			
Change in log employment ($\times$100)	Table 3	-14.4	-9.0
Change in log worker earnings ($\times$100)	Table 5	-0.8	-0.7
Change in log payroll ($\times$100)	Table 3	-12.1	-10.5
C. Interaction with concentration			
Change in log worker earnings (High concentration) ($\times$100)	Table 6	-3.1	-4.4
Change in log worker earnings (Medium concentration) ($\times$100)	Table 6	-0.8	-1.1
$\Delta HHI_j = \alpha + \widehat{\beta}\Delta HHI_j$, $\widehat{\beta}$	Table 8	0.834	0.893

Table 2: Mergers and replication of Arnold (2020)

6 Replicating empirical estimates of local labor market impacts

To demonstrate that our model is quantitatively consistent with the effects of mergers on various local labor market outcomes in the US, we compare our model's predictions to the empirical results found in the study by Arnold (2020). This study examines the employment responses of merging and non-merging firms within local labor markets and finds that (i) employment and wages decline and (ii) effects on earnings are larger in more concentrated markets.[18]

Replication. We replicate the empirical setting of Arnold (2020) as closely as possible in order to ensure a fair comparison. First, we draw and merge two firms in each market, recomputing the market equilibrium, and keeping aggregates fixed. Second, we keep all mergers where the average pre-merger employment of the two firms is greater than $\widetilde{n}$. We choose $\widetilde{n}$ such that median employment at pre-merger firms across all markets matches that in Arnold's estimation sample. To deliver median employment of 116 at pre-merger firms, we require $\widetilde{n}$ of 46. This is nearly five times the average firm employment, reflecting the fact that mergers tend to occur among larger firms. Third, we compute statistics using pre- and post-merger data exactly as in Arnold (2020).

Results. Table 2 shows that both qualitatively and quantitatively, our results are consistent with Arnold's findings. Panel A shows that by choosing $\widetilde{n}$, we exactly match on median employment pre-merger. This is important since the effects of mergers are heterogeneous across the size of firms. Panel B shows that the model lines up well with the main employment and wage results. The model generates three-fifths of the decline in employment estimated by Arnold (2020),

[18]Prediction (i) is a direct prediction of *Proposition 1*. In the case of prediction (ii), this could be established analytically in an environment with symmetric firms. However, equal market shares are inconsistent with the data. Hence we can only test this by simulation.

and a slightly larger decline in wages. Consistent with *Proposition 1*, firms' increased market power leads them to widen markdowns which reduces wages and reduces employment. With employment and wages falling, the total payroll at the merging firms also declines. Consistent with the data, small declines in wages generate large declines in employment, giving additional support to our estimates of labor supply elasticity parameters θ and η.

Panel B shows that the model is also quantitatively consistent with Arnold (2020)'s second prediction. Arnold (2020) divides markets into what he calls *high, medium* and *low impact markets*, where low impact markets have lower changes in market concentration after a merger, and high impact markets have large changes in market concentration as well as high initial levels of concentration.[19] Following Arnold (2020), we compute the change in worker earnings in high and medium concentration markets. Consistent with his results, we find effects are more than three times larger in high impact markets. Worker earnings fall by -4.4 percent in high concentration markets versus -1.1 percent in medium concentration markets. These estimates align quite closely with Arnold (2020)'s estimates of -3.1 percent and -0.8 percent, respectively.

The final row of Table 2 compares the relationship between the 'naive' prediction of the increase in concentration and the actual outcome. The naive prediction simply takes pre-merger shares and adds them up for the merging firms. As in the data, a merger in the model generates a smaller increase in concentration than the naive prediction (the estimated $\widehat{\beta}$ is less than one). *Proposition 1* rationalizes this result. Merging firms optimally cut back on employment, and non-merging firms expand, which dampens concentration relative to the naive prediction.

In summary, this analysis shows that our model is quantitatively consistent with the best available empirical evidence regarding the impact of mergers on labor market outcomes in the US. The close alignment between our model's predictions and empirical findings from studies like Arnold (2020) indicates that our model serves as a useful quantitative laboratory for examining potential merger guidelines. The empirical results from Arnold (2020) suggest that mergers in markets experiencing both high changes in concentration and high initial concentration might warrant further review. In the following sections, we assess this insight and attempt to provide useful quantitative insights for policymakers and regulators who are tasked with evaluating the potential impact of mergers on labor market outcomes.

[19] He defines *Low impact markets* as those with a change in employment concentration (ΔHHI_j) in the bottom three quantiles of changes in employment concentration. He defines *High impact markets* as those that are not low impact markets and additionally have an initial HHI_j above the median of non-Low impact markets. Medium impact markets are all remaining markets.

7 Penguin Random House Merger Simulation

To set the stage for our merger guideline section, we begin by computing the required efficiency gains for worker surplus neutrality in the *Penguin Random House* case.

Consistent with the details of the case, we construct a market in which the top player, *Penguin Random House* (PRH), has a 37 percent market share and merges with the third ranked firm *Simon & Schuster* (SS), which has a 12 percent market share. The remaining three firms' market shares are taken from Exhibit 963 (Pan, 2021, p. 27). We then solve for the resulting post-merger market level wage index under various levels of efficiency gains in equation (11).

Figure 1 plots the change in the market level wage index for various efficiency gains assumed in the *Penguin Random House* case (blue, crosses). Under our estimated parameters in Table 1, the merger generates a reduction in the market-level wage index for any efficiency gain below 17 percent. In the absence of any efficiency gain, the merger generates a five percent reduction in market-level worker (author) wages. Recall that worker surplus neutrality is only achieved when the change in wage index ($\mathbf{W}_j$) is zero. Thus the PRH/SS merger is only worker surplus neutral when the efficiency gains are 17 percent or greater. In other words, for any efficiency gain of less than 17 percent, the PRH/SS merger harms workers.

Figure 1 goes one step further and shows that substantial productivity gains would need to be demonstrated to achieve worker surplus neutrality for *any* merger in this market. A merger between the two largest publishers (green) generates even larger market-level wage losses of 10 percent in the absence of efficiency gains, with a required efficiency gain of 30 percent for worker (author) surplus neutrality. A merger between the two smallest Big Five publishers (red, circles) generates fewer wage losses but still has a substantial REG of 13 percent.

In the *Penguin Random House* case, the naive (pre-merger) estimate of the change in the Herfindahl index, ΔHHI, induced by the PRH and SS merger was 891, and the HHI exceeded 3,000. These concentration metrics far exceeded the 2010 guidelines for concentrated markets, leading to a prima facie presumption of anticompetitive effects. Consequently, the merger was blocked. Under standard efficiency gains of 5 percent, our simulations indicate this was the right decision: allowing the merger would have resulted in a worker surplus loss.

In what follows, we extend this analysis to a representative set of mergers in the U.S. based on Arnold (2020). Our focus is on assessing Herfindahl-based guidelines for mergers and how those guidelines should be drawn based on a regulator's priors on efficiency gains.

8 Merger guidelines

We use our quantitative framework to simulate a representative set of mergers in the U.S. and document the welfare, wage, and output implications under various merger review guidelines.

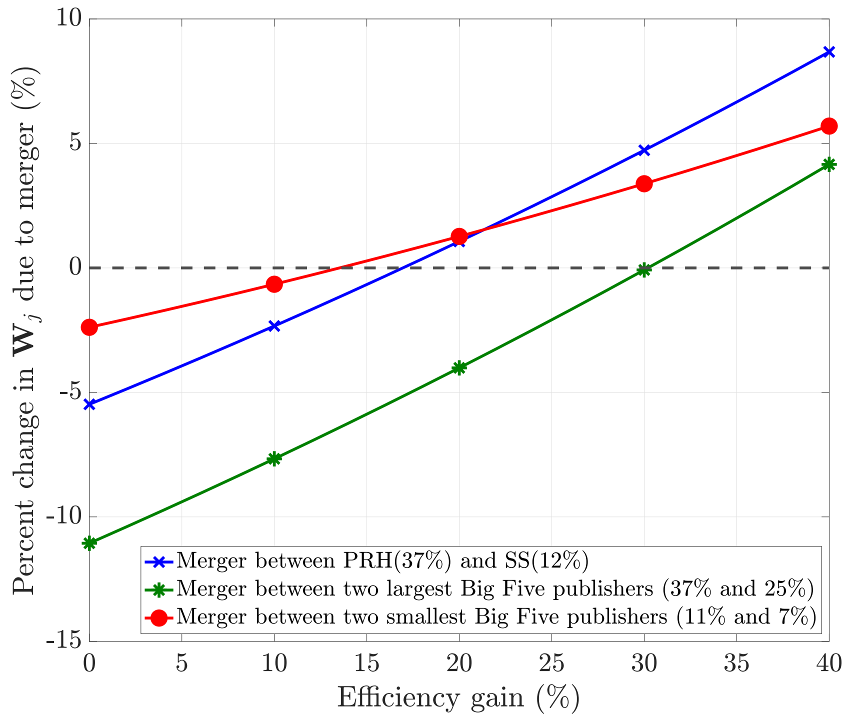

Figure 1: Expected change in wages in Penguin-Random-House & Simon-Schuster merger

Notes: Figures plot the merger-induced change in market-level wage index, $\mathbf{W}_j$, as a function of the assumed efficiency gain. The market structure mimics the *Penguin Random House* (PRH) and *Simon & Schuster* (SS) merger case based on Exhibit 963 (Pan, 2021, p. 27). The efficiency gain on the x-axis is applied to both merging plants as defined by equation (17).

Our results can then be used by regulators to determine optimal merger guidelines, including horizontal merger review thresholds for Herfindahls and changes in Herfindahls (DOJ and FTC, 2010).

Comparison of 1982 and 2010 guidelines. We begin by computing required efficiency gains (REGs) for worker surplus neutrality (i.e., for workers to be unharmed) when product market guidelines from 1982 and 2010 are applied to the labor market.

Based on the 1982 merger guidelines, the agencies and courts presumed anticompetitive effects[20] for mergers in product markets with a post-merger HHI greater than 1800 and a post-merger change in HHI (ΔHHI) greater than 100.[21] The 1982 guidelines also state that the DOJ

[20] The interpretation of the merger guidelines by courts is best exemplified in the *Penguin Random House* case (Pan, 2021): *"Under the Merger Guidelines, if an acquisition (1) increases the HHI of a relevant market by more than 200 points and (2) results in a post-acquisition HHI exceeding 2500, it is presumptively anticompetitive."* (p. 46)

[21] *Quoting from the DOJ and FTC (1982): "Post-Merger HHI Above 1800. Markets in this region generally are considered to be highly concentrated, having the equivalent of no more than approximately six equally sized firms. Additional concentration resulting from mergers is a matter of significant competitive concern, and the Department will resolve close questions in favor of challenging the merger. The Department is unlikely, however, to challenge mergers producing an increase in the HHI of less than 50 points. For mergers producing an increase in the HHI of from 50 to 100 points, the Department*

and FTC will sometimes, but not always, challenge mergers in markets with HHIs above 1000 and ΔHHIs above 100.

In the 2010 guidelines, the HHI and ΔHHI thresholds for presumed anticompetitive effects were increased to 2500 and 200, respectively. The 2010 guidelines also state that mergers in moderately concentrated markets with HHIs between 1500 and 2500 and ΔHHIs above 100 may be challenged.

Our main exercise is to apply the 1982 and 2010 product market merger thresholds to the labor market and compute the required efficiency gains for worker surplus neutrality under both sets of guidelines. Given some HHI and ΔHHI thresholds, our merger simulation proceeds as follows:

1. Draw $N = 200,000$ markets from the empirical distribution of markets in the United States. This includes the number of firms, distributed $G(M_j)$, and the productivity of firms within each market, distributed $F(z_{ij})$.
2. Randomly choose two candidate merging firms i and i'. Only consummate the merger if i and i''s average pre-merger employment is greater than $\tilde{n} = 46$. Imposing this size cutoff allows us to match the observed median merger size in Arnold (2020)'s representative sample of mergers in the U.S. (see Section 6 for additional details).[22]
3. Compute the required efficiency gain for worker surplus neutrality (Δ^*) in equation (11).
4. If the post-merger HHI and ΔHHI are above the specified thresholds, block the merger. Otherwise, the merger is permitted. When applying the guidelines, we naively compute post-merger HHIs by simply adding the pre-merger shares of i and i':

$$HHI' = \sum_{k \neq i,i'} s_{kj}^2 + (s_{ij} + s_{i'j})^2.$$

Hence, the naive Herfindahl change is given by,

$$\Delta HHI = (s_{ij} + s_{i'j})^2 - (s_{ij}^2 + s_{i'j}^2).$$

Table 3 provides the average required efficiency gain (Δ^*) for worker surplus neutrality and the change in the market-level wage index $\mathbf{W}_j$ when mergers are blocked according to the 1982 and 2010 thresholds for HHI and ΔHHI. These statistics are computed separately for markets in which firms are permitted to merge and markets in which mergers are blocked.

will base its decision whether to challenge the merger on the post-merger concentration of the market, the size of the resulting increase in concentration, and the presence or absence of the factors discussed in Sections III (8) and III (C)."

[22] Note that the lower employment threshold of $\tilde{n} = 46$ in this section is estimated so that the median pre-merger employment of the merging firms is 116.

	A. 1982 guidelines		B. 2010 guidelines	
DOJ/FTC market classification	Moderate	High	Moderate	High
Threshold (HHI, ΔHHI)	(1000, 100)	(1800, 100)	(1500, 100)	(2500, 200)
	(1)	(2)	(3)	(4)
I. Average REG				
Permitted mergers	3.50	4.68	4.16	5.96
Blocked mergers	18.73	19.97	19.35	22.88
II. Change in average $\mathbf{W}_j$ assuming 1 percent efficiency gain (%)				
Permitted mergers	-0.23	-0.40	-0.32	-0.63
Blocked mergers	-6.01	-7.39	-6.71	-10.37
III. Change in average $\mathbf{W}_j$ assuming 2 percent efficiency gain (%)				
Permitted mergers	-0.13	-0.29	-0.21	-0.51
Blocked mergers	-5.71	-7.04	-6.39	-9.93
IV. Change in average $\mathbf{W}_j$ assuming 3 percent efficiency gain (%)				
Permitted mergers	-0.02	-0.18	-0.11	-0.39
Blocked mergers	-5.42	-6.70	-6.07	-9.49
V. Change in average $\mathbf{W}_j$ assuming 4 percent efficiency gain (%)				
Permitted mergers	0.08	-0.07	0.00	-0.27
Blocked mergers	-5.12	-6.35	-5.74	-9.05
VI. Change in average $\mathbf{W}_j$ assuming 5 percent efficiency gain (%)				
Permitted mergers	0.19	0.04	0.11	-0.14
Blocked mergers	-4.82	-5.99	-5.41	-8.61

Table 3: Comparison of 1982 and 2010 guidelines.

Notes. Merger simulation designed to match representative set of firms based on Arnold (2020), see text for details. Panel A applies the 1982 guidelines. In Column (1), all mergers with post-merger concentration/change in concentration above ($HHI = 1000, \Delta HHI = 100$) are blocked. In Column (2), all mergers with post-merger concentration/change in concentration above ($HHI = 1800, \Delta HHI = 100$) are blocked. Panel B applies 2010 guidelines. In Column (3), all mergers with post-merger concentration/change in concentration above ($HHI = 1500, \Delta HHI = 100$) are blocked. In Column (2), all mergers with post-merger concentration/change in concentration above ($HHI = 2500, \Delta HHI = 200$) are blocked. Panel I reports the average required efficiency gain for worker surplus neutrality. $\mathbf{W}_j$ is the industry level wage index given by equation (4). Panels II through VI report average change in $\mathbf{W}_j$ when the merger generates an efficiency gain of $\{1\%, 2\%, 3\%, 4\%, 5\%\}$ at both plants, as defined by equation (17).

The first two columns of Table 3 refer to the screening thresholds in the 1982 merger guidelines. We begin with the most stringent guidelines in column (1) (i.e., thresholds that correspond to moderately concentrated markets). Panel I demonstrates that if we impose the most stringent threshold from DOJ and FTC (1982) and block mergers that generate post-merger HHIs above 1000 and that raise the HHI by more than 100, the average REG of permitted mergers is 3.50 percent. Consequently, under this threshold rule, permitted mergers must generate an average efficiency gain of 3.50 percent in order to yield worker surplus neutrality. On the other hand, blocked mergers must generate a much larger average REG of 18.73 percent for worker surplus neutrality.

Panel II shows that under an assumed efficiency gain of 1 percent at both plants of the newly merged firm, permitted mergers lower the market-level wage index by -0.23 percent. Under an assumed efficiency gain of 1 percent, the blocked mergers lower the market-level wage index by -6.01 percent. Recall that to achieve worker surplus neutrality, the market-level wage index must remain above its pre-merger level. Thus, under an assumed efficiency gain of 1 percent, the permitted mergers yield worker surplus losses. This should not be surprising since 1 percent is less than the associated REG. At the other extreme, Panel VI shows that under an assumed efficiency gain of 5 percent, permitted mergers raise average wages by 0.19 percent and therefore yield worker surplus gains, while blocked mergers still lower the market-level wage index by -4.82 percent.

Column (2) applies the less stringent merger thresholds from the 1982 guidelines (i.e., thresholds that correspond to highly concentrated markets). In column (2), we block mergers that generate post-merger HHIs above 1800 and that raise the HHI by more than 100, and we find that the average REG of permitted mergers is 4.68 percent. Under this threshold rule, permitted mergers must generate an average productivity gain of 4.68 percent for worker surplus neutrality. Therefore, under the standard assumed efficiency gain of 5 percent, permitted mergers yield worker surplus gains and raise the market-level wage index by 0.04 percent. Blocked mergers yield worker surplus losses and lower the market-level wage index by -5.99 percent.

The last two columns of Table 3 refer to the screening thresholds in the 2010 merger guidelines. In column (3) we impose the most stringent thresholds from DOJ and FTC (2010) and block mergers that generate post-merger HHIs above 1500 and that raise the HHI by more than 100. Under these guidelines, Panel I demonstrates that the average REG of permitted mergers is 4.16 percent.

If we impose the least stringent threshold from DOJ and FTC (2010) and block mergers that result in post-merger HHIs above 2500 and that raise the HHI by more than 200, the average REG of permitted mergers is 5.96 percent. This implies that under the standard assumed efficiency gain of 5 percent, permitted mergers yield worker surplus losses. The market-level wage index falls by -0.14 percent among permitted mergers and -8.61 percent for blocked mergers. Comparing columns (2) and (4), it is clear that the high concentration definition in the 1982 guidelines ($HHI = 1800, \Delta HHI = 100$) allows mergers that yield market-level wage gains (and are thus worker surplus neutral), whereas the less stringent high concentration definition in the 2010 guidelines ($HHI = 2500, \Delta HHI = 200$) allows mergers that yield market-level wages losses (and are therefore *not* worker surplus neutral).

Table 3 yields several implications for optimal policy under standard assumed efficiency gains of 5 percent. If the objective of the DOJ and FTC is to conserve resources by reviewing only those mergers most likely to harm workers while ensuring that workers are unharmed by permitted mergers, then the 1982 guidelines of ($HHI = 1800, \Delta HHI = 100$) achieve that goal, whereas the 2010 guidelines ($HHI = 2500, \Delta HHI = 200$) do not. More generally, Table 3 can be combined with regulators' priors on efficiency gains in order to form optimal policy prescriptions.

Confidence levels of guidelines. Figure 2 takes a different approach and instead fixes a post-merger efficiency gain at 5 percent and then asks what fraction of mergers would yield worker surplus gains, weakly. The x-axis is the merger-induced change in the Herfindahl and the y-axis is the merger-induced level of the Herfindahl.

Assuming a 5 percent efficiency gain, each cell of Figure 2A reports the fraction of mergers that yield a worker surplus gain, conditional on various post-merger HHIs and ΔHHIs. For example, if merger efficiency gains are assumed to be 5 percent, the southwest-most cell of Figure 2A demonstrates that 89.5 percent of mergers in which the post-merger HHI is less than 500 and the change in HHI is less than 50 yield a worker surplus gain. Consider the 2010 merger guideline definition of a highly concentrated market. If merger efficiency gains are assumed to be 5 percent, *less than* 34.8 percent of simulated mergers in which $\Delta HHI_j > 100$ and $HHI_j > 2500$ generate a worker surplus gain. For a desired level of confidence, a regulator can read off the required thresholds.

Figure 2B conducts the same exercise, except the cells correspond to various payroll shares of the two merging firms. The x-axis (y-axis) reports the smaller (larger) firm's share of local payroll. Assuming a 5 percent efficiency gain, only 12 percent of mergers in which the smaller firm's payroll share exceeds 5 percent yield a worker surplus gain.

Note that the probabilities in Figure 2B are due to the distribution of market-level characteristics outside of the shares of the small and large firms. Some markets also have a large third competitor and hence have a higher REG. Some markets have many small competitors and hence have a lower REG. Additional information can be brought in to narrow down these

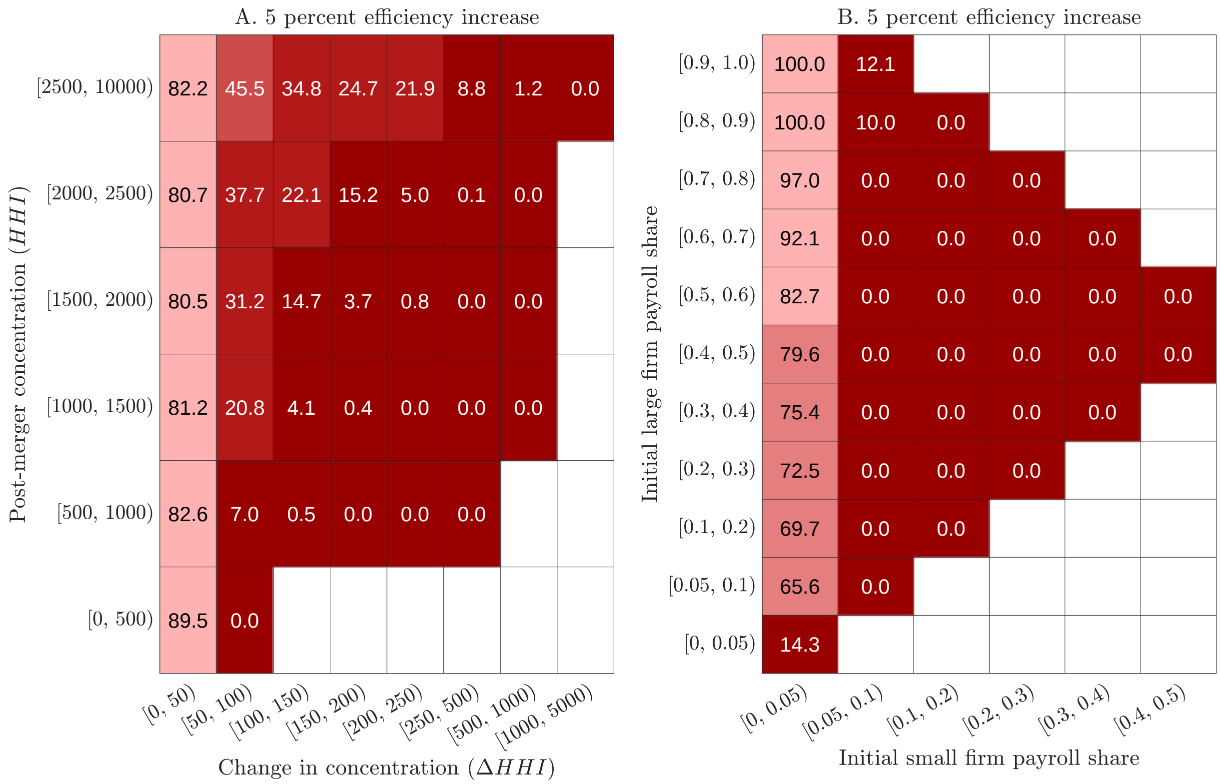

Figure 2: Fraction of mergers yielding worker surplus gain for 5 percent efficiency gain

Notes. Merger simulation designed to match representative set of firms based on Arnold (2020), see text for details. Post-merger HHI (y-axis) and ΔHHI (x-axis) are computed naively using the combined pre-merger shares of the merging firms. Panel A reports the fraction of mergers that are worker surplus neutral when the merger generates an efficiency gain of 5 percent at both plants, as defined by equation (17). Panel B repeats the same exercise as Panel A, except Panel B stratifies by the merging firms' pre-merger local payroll market shares. The x-axis is the local payroll of the smaller of the two merging firms.

probabilities and make more informed merger review decisions.

For a given level of "Type I" error tolerance and a given level of merger efficiency gains, regulators can use our figures to determine optimal policy. For example, if presented with a merger with an initial small firm share of 4 percent and a large firm share of 18 percent, Figure 6 says that under an assumed productivity gain of 5 percent there is a 69.7 percent chance that the merger yields a worker surplus gain. Appendix Figure 7 shows that there is a 97.7 percent chance of a worker surplus gain under an efficiency gain of 10 percent. Hence, based on the regulator's tolerance for risk and priors on merger efficiency gains, regulators may use Figures 5 through 6 to determine which mergers should be reviewed.

Alternate thresholds, employment, output, and welfare. The Appendix to this paper provides a number of more detailed tables and merger thresholds based on alternative efficiency gains.

Appendix D provides uni-dimensional merger guidelines based on HHIs alone or ΔHHI's alone. Appendix E analyzes the output response to mergers. Appendix F analyzes the employment response to mergers. In Appendix G, we provide an approximation to market-level worker welfare, and we report how merger guidelines affect market-level worker welfare. Since our preferences are linear in consumption (see Section 5), the worker welfare metrics are in 2014 dollars. Lastly, in Appendix H, we provide type I and type II error rates for both the 1982 and 2010 merger guidelines.

9 Downward wage pressure

In the product market, *upwards price pressure* and *gross upwards price pressure indexes* are commonly referenced metrics to evaluate the effects of mergers on consumers (e.g. Farrell and Shapiro, 2010; Naidu, Posner, and Weyl, 2018). In this section, we mirror the product market approach. We define and then derive closed-form share-based formulas for *downwards wage pressure* and *gross downwards wage pressure*.

Downward wage pressure. To derive the first of our formulas, we combine and rearrange the first order conditions of the merged firm's optimal employment choice at Plant 1 (equation 9). This yields the following expression for wages (a symmetric equation exists for Plant 2):

$$w_{1j} = \left(\frac{\varepsilon_{1j}}{\varepsilon_{1j}+1}\right)\left(z_{1j} - \underbrace{n_{2j}\frac{\partial w_{2j}}{\partial n_{1j}}}_{:=\text{Downward wage pressure}}\right) \tag{14}$$

We formally define downward wage pressure to be the term $n_{2j}\frac{\partial w_{2j}}{\partial n_{1j}}$. This term is equivalent to a per-worker, lump-sum *labor cannibalization tax*.[23] What generates this tax? When the newly merged firm hires at Plant 1, it must pay higher wages at Plant 2 to keep employment constant at Plant 2. Since there are n_{2j} workers employed at Plant 2, the total increase in costs for Plant 2 is $n_{2j}\frac{\partial w_{2j}}{\partial n_{1j}}$. Before the merger, this does not enter either firm's wage-setting decision. After the merger, the merged firm's objective is to maximize the combined profits of Plants 1 and 2, in which case it internalizes this effective tax, thus lowering the marginal benefit of hiring at both plants.

Using the labor supply system, we can express the Downward Wage Pressure term in (14)

[23] To see this, consider a single plant that chooses n_{1j} to maximize $\pi_{1j} = z_{1j}n_{1j} - (w_{1j}+\overline{\tau})n_{1j}$, where $\overline{\tau}$ is a per-worker payroll tax. When the first order condition is evaluated at $\overline{\tau} = n_{2j}\frac{\partial w_{2j}}{\partial n_{1j}}$, the equivalence of the first order conditions at Plant 1 follows immediately.

as a share-based formula (a symmetric equation defines DWP_{2j} at Plant 2):

$$\text{DWP}_{1j} := n_{2j}\frac{\partial w_{2j}}{\partial n_{1j}} = w_{1j}\left(\frac{1}{\theta}-\frac{1}{\eta}\right)s_{2j} \tag{15}$$

Thus downward wage pressure at Plant 1 is a simple function of Plant 2's payroll share of the local labor market, Plant 1's wage rate, and labor substitutability parameters η and θ (of which estimates are provided in Table 1). Intuitively, the larger the share of Plant 2 in the labor market, the greater the downward wage pressure. Likewise, the larger the degree of substitutability across plants within the market (i.e., higher η), the greater the downward wage pressure. High values of η imply high degrees of head-to-head competition. When firms that engage in more head-to-head competition merge, small wage changes more aggressively reallocate employment, increasing this 'tax'.

Gross downward wage pressure. Unfortunately, the DWP defined in equation (15) is in wage units, making its cardinal value difficult to interpret in practice. This leads us to define the gross downward wage pressure index. To derive the gross downward wage pressure index (GDWPI), we simply divide equation (15) by w_{1j}:

$$\text{GDWPI}_{1j} := \frac{\text{DWP}_{1j}}{w_{1j}} = \left(\frac{1}{\theta}-\frac{1}{\eta}\right)s_{2j}, \qquad \text{GDWPI}_{1j} \in [0, \theta^{-1}-\eta^{-1}] \tag{16}$$

The GDWPI yields a particularly simple interpretation of downward wage pressure as a tax rate on the wages of workers at Plant 1.[24] When Plant 1 hires, market wages increase, causing the labor costs at Plant 2 to increase. GDWPI_{1j} summarizes this extra cost of wages at Plant 2 as a fraction of wages at Plant 1. Hence, we treat GDWPI_{1j} as a wage tax and express it in percentage terms. Given its sole dependence on the merging plants' local labor market shares, this formula can be readily applied to any industry with appropriate estimates of within- and across-market substitutability (η and θ). For an initial merger review, our economy-wide estimates of η and θ are a good benchmark.[25]

Figure 3 plots the required efficiency gains (REGs) for worker surplus neutrality (Δ^*) as a

[24] To see this, consider a single plant that chooses n_{1j} to maximize

$$z_{1j}n_{1j} - (w_{1j}+\overline{\tau})n_{1j}.$$

Taking FOCs, we have $z_1 - \overline{\tau} - w_1(\varepsilon^{-1}+1) = 0$. This can be rearranged to see $z_1 - \overline{\tau}\frac{w_1}{w_1} - w_1(\varepsilon^{-1}+1) = z_1 - w_1(\varepsilon^{-1}+1+\frac{\overline{\tau}}{w_1}) = 0$. Hence $\overline{\tau}/w_1$ has the interpretation of a tax on worker wages. Letting $\overline{\tau} = n_{2j}\frac{\partial w_{2j}}{\partial n_{1j}}$ yields the GDWPI.

[25] Recall from Table 1, $\theta = 0.45$, and $\eta = 10.85$, giving $\theta^{-1} - \eta^{-1} = 2.29$.

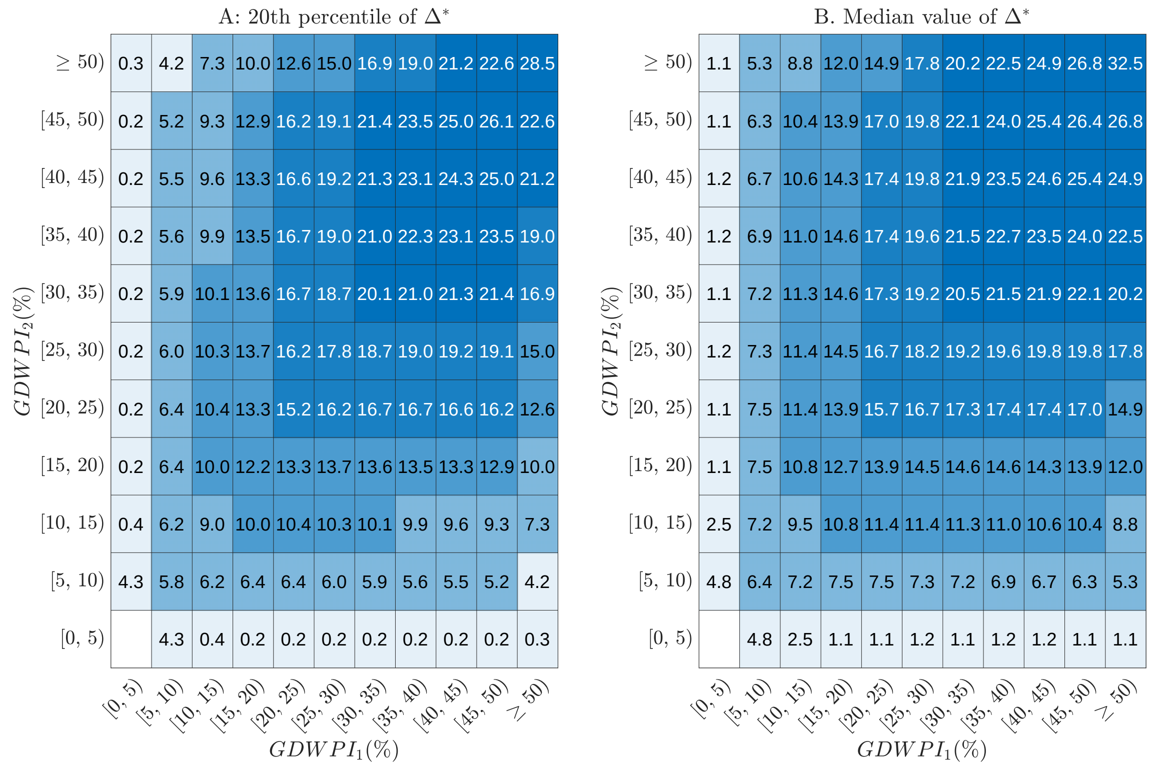

Figure 3: Productivity gains necessary to yield worker surplus neutrality stratified by gross downward wage pressure at each of the merging plants. The gross downward wage pressure is defined by equation (16), and multiplied by 100

function of both plants' gross downward wage pressure (defined by equation 16). Figure 3 is constructed as follows:

1. For each of the 200,000 simulated mergers n in Section 8, compute the gross downward wage pressure index (GDWPI) for each plant using equation (16).[26]
2. Additionally, for each merger, compute the REG, Δ_n^*, necessary for worker surplus neutrality and store these in a vector $\{\Delta_n^*\}$.
3. Bin mergers based on the recorded GDWPI value at each plant. Without loss of generality, the x-axis is the GDWPI at Plant 1, the y-axis is the GDWPI at Plant 2.
4. For all mergers that have a given GDWPI combination at Plant 1 (x-axis) and Plant 2 (y-axis), Figure 3A reports the 20th percentile of the REG distribution, $\{\Delta_n^*\}$, while Figure 3B reports the median of the REG distribution.

[26]As in Section 8, we only consummate the merger if i and i''s average pre-merger employment is greater than $\tilde{n} = 46$ in order to match the observed median merger size in Arnold (2020)'s representative sample of mergers in the U.S.

For example, consider the second diagonal element of Figure 3A, which corresponds to mergers in which the GDWPI lies between 5 percent and 10 percent at both plants. There are thousands of simulated mergers for which $\text{GDWPI}_{1j} \times 100 \in [5, 10)$ and $\text{GDWPI}_{2j} \times 100 \in [5, 10)$. Among all of those mergers, Panel A of Figure 3 reports the 20th percentile REG Δ^* and Panel B of Figure 3 reports the median Δ^*. In Panel A, the 20th percentile REG among those mergers is 5.8 percent. This means that if regulators assumed that firms' productivity increased by 5.8 percent following a merger, then worker surplus neutrality only occurs in 20 percent of consummated mergers in which both firms' GDWPI is between 5 and 10 percent. Panel B shows that the *median* Δ_n^* among those mergers is 6.4 percent. If regulators assumed that firms' productivity increased by 6.4 percent following a merger, then 50 percent of mergers in which firms' GDWPI is between 5 and 10 percent yield worker surplus neutrality and therefore leave workers unharmed.

Consider mergers in which the GDWPI is more than 10 percent at both plants. Among all mergers in the upper quadrant of Panel A of Figure 3, the 20th percentile of Δ^* is bound below by 7.30 percent. In other words, if we take mergers that induce gross downward wage pressure of 10 percent or more at both plants, then more than 80 percent of these mergers would generate a welfare loss under an assumed efficiency gain of 5 percent.

10 Conclusion

This paper provides a quantitative framework of multi-plant ownership and monopsony. We use the framework to theoretically characterize the effects of mergers on employment, wages, and worker surplus. We calibrate our model economy to the United States and show that the model generates empirical patterns consistent with recent causal analysis of the labor market effects of mergers (Arnold, 2020), including how post-merger employment and wage losses vary by observable characteristics like concentration. Having validated our model, we then simulate a representative set of mergers in the United States and conduct a variety of merger review exercises.

Our main exercise compares the 1982 and 2010 product market merger review guidelines when applied to the labor market. Under a standard assumed efficiency gain of 5 percent, our framework suggests that more stringent guidelines in the labor market are required for worker surplus neutrality. If the objective of the DOJ and FTC is to conserve resources by reviewing only those mergers most likely to harm workers while ensuring that workers are unharmed by permitted mergers, then the 1982 guidelines in which mergers are presumed anticompetitive whenever post-merger concentration exceeds $(HHI = 1800, \Delta HHI = 100)$ achieve that goal. On the other hand, the 2010 guidelines in which mergers are presumed anticompetitive whenever post-merger concentration exceeds $(HHI = 2500, \Delta HHI = 200)$ do not achieve that goal.

More generally, the tables in this paper and associated appendices can be combined with regulators' priors on efficiency gains in order to form optimal policy prescriptions. For a given level of "Type I" error tolerance and merger efficiency gain, regulators can use our figures to compute what fraction of mergers would yield worker surplus losses or gross downward wage pressure. Based on the regulator's tolerance for risk and priors on merger efficiency gains, the results provided in this paper can inform regulators as to which mergers should be reviewed based on thresholds for observable local labor market Herfindahls, changes in local labor market Herfindahl mergers, and the degree of gross downward wages pressure induced by the merger.

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Online Appendix

A Proof - Proposition 3.1

- In this section we prove the claims in Proposition 3.1. These are listed in a different order in Proposition 3.1, but here listed in the order that they are proved:

  1. Following a merger, the markdowns at the merged firms are equalized and depend on the total market share, $\mu_{1j} = \mu_{2j} = \mu\left(s_{1j} + s_{2j}\right)$.
  2. Under either monopsony limit a merger has no effect on any labor market variables.
  3. The individual shares s_{ij} of all non-merging firms increase. Therefore the total market share of merging firms falls.
  4. The wage index of non-merging firms decreases and employment index increases.
  5. Market wage $\mathbf{W}_j$ and employment $\mathbf{N}_j$ decline, so total market pay $\mathbf{W}_j\mathbf{N}_j = \sum_{i \in j} w_{ij} n_{ij}$ declines.
  6. The wages of both merging firms w_{1j} and w_{2j} decline. The wage index of merging firms decreases and employment index decreases.

- Parts 1 and 2 we prove under decreasing returns to scale. The remainder we establish under constant returns to scale. The proof of Part 3 is the most involved, and remaining parts follow from Part 3 in a straight-forward manner.

Proposition 3.1, Part 1: Common markdown.

- Throughout we assume $M_j \geq 3$, and assign $i = 1$ and $i' = 2$ to the two merging firms.

- A merged firm chooses employment at both firms to maximize profits, where without loss of generality for this proof we can consider the case of a production function $f(\cdot)$ that already incorporates the (competitive) intermediate and capital choices

$$\max_{n_{1j}, n_{2j}} \left[f\left(z_{1j}, n_{1j}\right) - w\left(n_{1j}, \mathbf{N}_{-1j}\right) n_{1j}\right] + \left[f\left(z_{2j}, n_{2j}\right) - w\left(n_{2j}, \mathbf{N}_{-2j}\right) n_{2j}\right]$$

- When taking the first order condition, the firm understands that n_{2j} appears in $\mathbf{N}_{-1j}$ and vice versa.

- The first order condition for n_{1j} is as follows, where we use $mrpl_{1j} = f_n\left(z_{1j}, n_{1j}\right)$ to denote the marginal revenue product of labor

$$\left(mrpl_{1j} - \frac{\partial w_{2j}}{\partial n_{1j}} n_{2j}\right) = \frac{\partial w_{1j}}{\partial n_{1j}} n_{1j} + w_{1j}$$

- Written this way we can see that in understanding that increasing n_{1j} increases the wage at Firm 2, maps into an effective reduction in productivity at Firm 1.

- Recall that

$$w_{1j} = n_{1j}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} \boldsymbol{X}$$
$$w_{2j} = n_{2j}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} \boldsymbol{X}$$

- Using this expression

$$mrpl_{1j} - w_{1j} = \left(\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) s_{1j}\right) w_{1j} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) s_{1j} \frac{w_{2j} n_{2j}}{n_{1j}}$$
$$mrpl_{1j} - w_{1j} = \left(\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) s_{1j}\right) w_{1j} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) s_{2j} w_{1j}$$
$$mrpl_{1j} - w_{1j} = \left[\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right)\left(s_{1j} + s_{2j}\right)\right] w_{1j}$$

- Therefore $w_{1j} = \mu\left(s_{1j} + s_{2j}\right) mrpl_{1j}$. Note that the same algebra can be applied to Firm 2. Therefore this establishes the first result:

$$\mu'_{1j} = \mu'_{2j} = \mu\left(s'_{1j} + s'_{2j}\right)$$

- Note that the above algebra generalizes in a straight-forward way to the case of an arbitrary set of firms merging. Let the set of merging firms be A, then

$$\mu'_{ij} = \mu\left(\boldsymbol{s}'_{jA}\right) \quad \boldsymbol{s}'_{jA} = \sum_{i \in A} s'_{ij}.$$

□

Proposition 3.1, Part 2: No effect of mergers in monopsony

- Consider the above problem of the merged firm in a monopsonistically competitive labor market

$$\max_{n_{1j},n_{2j}} \left[f\left(z_{1j},n_{1j}\right)-w\left(n_{1j}\right)n_{1j}\right]+\left[f\left(z_{2j},n_{2j}\right)-w\left(n_{2j}\right)n_{2j}\right]$$

- Here the wage depends on $\mathbf{N}_j$ but since the firm is infinitesimal, it does not internalize its effect on $\mathbf{N}_j$.

- The first order condition for Firm 1 employment is:

$$mrpl_{1j}=w'\left(n_{1j}\right)n_{1j}+n_{1j}$$

- This is identical to the first order condition of Firm 1 in the pre-merger economy. Therefore there is no effect at all on employment and wages.

□

Definitions required for Proposition 3.1, Parts 3 through 6: We begin by defining **Groups** - A useful concept is that of a grouping within a market. Split the firms in the market into those that merge $i \in A$, and those that don't merge $i \in B$.

- Define the group-level employment and wage indexes:

$$\mathbf{N}_{jG}=\left[\sum_{i\in G} n_{ij}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}} \quad , \quad \mathbf{W}_{jG}=\left[\sum_{i\in G} w_{ij}^{\eta+1}\right]^{\frac{1}{\eta+1}} \quad , \quad G\in\{A,B\}$$

- It is straight-forward to use these definitions to show that the market indices are

$$\mathbf{N}_j=\left[\mathbf{N}_{jA}^{\frac{\eta+1}{\eta}}+\mathbf{N}_{jB}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}} \quad , \quad \mathbf{W}_j=\left[\mathbf{W}_{jA}^{\eta+1}+\mathbf{W}_{jB}^{\eta+1}\right]^{\frac{1}{\eta+1}}$$

- These can then be used to derive *group level* supply curves and share relationships:

$$\mathbf{N}_{jG}=\left(\frac{\mathbf{W}_{jG}}{\mathbf{W}_j}\right)^{\eta}\mathbf{N}_j \ , \ \mathbf{W}_{jG}\mathbf{N}_{jG}=\sum_{i\in G} w_{ij}n_{ij} \ , \ \mathbf{s}_{jG}:=\frac{\sum_{i\in G} w_{ij}n_{ij}}{\sum_{i\in j} w_{ij}n_{ij}}=\sum_{i\in G} s_{ij}=\left(\frac{\mathbf{W}_{jG}}{\mathbf{W}_j}\right)^{\eta+1}=\left(\frac{\mathbf{N}_{jG}}{\mathbf{N}_j}\right)^{\frac{\eta+1}{\eta}}$$

- For individual firms, then we can allocate labor relative to the group, and derive a *relative share* $\widetilde{s}_{iG}$ of group wages, which we can show is equal to overall market share divided by group market share.

$$n_{ij} = \left(\frac{w_{ij}}{\mathbf{W}_{jG}}\right)^{\eta} \mathbf{N}_{jG} \ , \ \widetilde{s}_{iG} := \frac{w_{ij}n_{ij}}{\sum_{i\in G} w_{ij}n_{ij}} = \left(\frac{w_{ij}}{\mathbf{W}_{jG}}\right)^{\eta+1} = \frac{s_{ij}}{\boldsymbol{s}_{jG}}$$

<u>**Lemmas required for Proposition 3.1, Parts 3 through 6:**</u> We can use these definitions to establish three Lemmas that will be useful in proving the remaining content of the proposition. Proofs for each Lemma is at the end of this appendix.

- **Lemma 1 -** *Consider some change in a market that* ***directly*** *effects some group of firms* $i \in A$. *Then the shares of* ***all other*** *firms* $i \in B = \mathcal{I} \backslash A$, *change in the same direction.* ***(Proof at the end of this appendix)***

- **Lemma 2** - *Assume* $z_{1j} > z_{2j}$, *then merging firms satisfy the following properties* ***(Proof at the end of this appendix)***:

  1. *In terms of wage changes:* $\Delta \log w_{1j} > \Delta \log w_{2j}$ (Lemma 2.1)
  2. *The relative share of the most productive merging firm increases* $\widetilde{s}'_{1A} > \widetilde{s}_{1A}$. (Lemma 2.2)

- **Lemma 3** - *For non-merging firms, if* $s'_{ij} > s_{ij}$ *then* $n'_{ij} > n_{ij}$. ***(Proof at the end of this appendix)***

<u>Proposition 3.1, Part 3</u>**: Shares of all non-merging firms increase. Therefore the combined share of merging firms falls.**

- Applying **Lemma 1**, we know that the shares of non-merging firms either (i) *all decrease*, or (ii) *all increase*. We proceed by contradiction. **Suppose**: All non-merging firms' shares *decrease*: $s'_{ij} < s_{ij}$ for all $i \in B$.

  1. Since all non-merging firms' shares decrease then $\boldsymbol{s}'_{jB} < \boldsymbol{s}_{jB}$. Since $\boldsymbol{s}_{jA} + \boldsymbol{s}_{jB} = 1$, then the total share of merging firms increases: $\boldsymbol{s}'_{jA} > \boldsymbol{s}_{jA}$. From **Lemma 2.2** we know that the relative share of the most productive merging firm increases: $\widetilde{s}'_{1A} > \widetilde{s}_{1A}$. Since $s_{1j} = \widetilde{s}_{1A}\boldsymbol{s}_{jA}$, and $\boldsymbol{s}_{jA}$ increases, then $s'_{1j} > s_{1j}$ $(*)$. Since $\boldsymbol{s}'_{jA} > \boldsymbol{s}_{jA}$, then by definition

$$s'_{1j} + s'_{2j} > s_{1j} + s_{2j}$$

therefore

$$\mu\left(s'_{1j}+s'_{2j}\right)z_{1j}<\mu\left(s_{1j}+s_{2j}\right)z_{1j}$$
$$w'_{1j}<w_{1j}\quad(**)$$

Combined $(*)$ and $(**)$ imply that Firm 1's wage is falling, while its share is increasing. Since $s_{ij}=\left(w_{ij}/\mathbf{W}_j\right)^{1+\eta}$, this requires the market wage to be falling: $\mathbf{W}'_j<\mathbf{W}_j$ (#).

2. By our supposition, all non-merging firms shares decrease, $s'_{ij}<s_{ij}$, which since $w'_{ij}=\mu\left(s'_{ij}\right)z_{ij}$, implies that $w'_{ij}>w_{ij}$ for all non-merging firms. But since $s_{ij}=\left(w_{ij}/\mathbf{W}_j\right)^{1+\eta}$, then if $s'_{ij}<s_{ij}$ and $w'_{ij}>w_{ij}$, then it must be that $\mathbf{W}'_j>\mathbf{W}_j$ (##).

- **Contradiction**. The market wage can not be increasing (#) and decreasing (##).
- Therefore all non-merging firms' shares *increase.* It is then immediate that the *combined* share of the merging firms decrease: $\boldsymbol{s}'_{jA}<\boldsymbol{s}_{jA}$.

□

Proposition 3.1, Part 4: Wage index of non-merging firms $\mathbf{W}_{jB}$ decreases, and employment index $\mathbf{N}_{jB}$ increases Consider a non-merging firm $i\in B$. Since z_{ij} is fixed, and by the above $s'_{ij}>s_{ij}$, then $\mu\left(s'_{ij}\right)<\mu\left(s_{ij}\right)$, so $w'_{ij}<w_{ij}$. Since $\mathbf{W}_{jB}^{1+\eta}=\sum_{i\in B}w_{ij}^{1+\eta}$, then the wage index of non-merging firms decreases: $\mathbf{W}'_{jB}<\mathbf{W}_{jB}$. From **Lemma 3**, since $s'_{ij}>s_{ij}$, then $n'_{ij}>n_{ij}$. Since $\mathbf{N}_{jB}^{(\eta+1)/\eta}=\sum_{i\in B}n_{ij}^{(\eta+1)/\eta}$, then $\mathbf{N}'_{jB}>\mathbf{N}_{jB}$.

□

Proposition 3.1, Part 5: Market wage $\mathbf{W}_j$ and market employment $\mathbf{N}_j$ both decrease Since for non-merging firms their share is increasing $s'_{ij}>s_{ij}$ while their wages are falling $w'_{ij}<w_{ij}$, and $s_{ij}=\left(w_{ij}/\mathbf{W}_j\right)^{1+\eta}$, then it must be that the market wage is falling: $\mathbf{W}'_j<\mathbf{W}_j$. Since $\mathbf{W}'_j<\mathbf{W}_j$, then by market labor supply $\mathbf{N}'_j<\mathbf{N}_j$.

□

Proposition 3.1, Part 6: The wages of both merging firms w_{1j} and w_{2j} fall. The merging firms' index $\mathbf{W}_{jA}$ and employment index $\mathbf{N}_{jA}$ falls.

- From **Lemma 2.1**, we know that $\Delta \log w_{1j} > \Delta \log w_{2j}$.
  - Suppose that $w'_{2j} > w_{2j}$. Then the above implies that $w'_{1j} > w_{1j}$. Since $\mathbf{W}'_j < \mathbf{W}_j$ while the merging firms' wages are increasing, then both merging firms' shares increase because $s_{ij} = \left(w_{ij}/\mathbf{W}_j\right)^{1+\eta}$. This would imply that $\mathbf{s}'_{jA} > \mathbf{s}_{jA}$. **Contradiction** (Since we have already shown that the total share of merging firms decreases). Therefore $w'_{2j} < w_{2j}$.
  - Suppose that $w'_{1j} > w_{1j}$, this requires $\mu\left(s'_{1j} + s'_{2j}\right) > \mu\left(s_{1j}\right)$, which requires that $s'_{1j} + s'_{2j} < s_{1j}$. This requires $s'_{1j} < s_{1j}$. But we have shown that $\mathbf{W}'_j < \mathbf{W}_j$, so if $w'_{1j} > w_{1j}$, then $s'_{1j} > s_{1j}$. **Contradiction**. Therefore $w'_{1j} < w_{1j}$.
- Therefore $w'_{1j} < w_{1j}$ and $w'_{2j} < w_{2j}$. Since both firms' wages fall, then $\mathbf{W}'_{jA} < \mathbf{W}_{jA}$. Since the market employment index $\mathbf{N}'_j < \mathbf{N}_j$, but the employment index of non-merging firms increases $\mathbf{N}'_{jB} > \mathbf{N}_{jB}$, then it must be that $\mathbf{N}'_{jA} < \mathbf{N}_{jA}$.

□

Proofs of Lemmas Lemma 1 - *Consider some change in a market that* ***directly*** *effects some group of firms $i \in A$. Then the shares of* ***all other*** *firms $i \in B = \mathcal{I} \backslash A$, change in the same direction.*

- **Proof**: Suppose not. Then there are two firms $i, k \in B$ such that $s'_{ij} > s_{ij}$ and $s'_{kj} < s_{kj}$.
- For firm i, since $s'_{ij} > s_{ij}$, then $\mu\left(s'_{ij}\right) < \mu\left(s_{ij}\right)$, so $w'_{ij} < w_{ij}$. From $s_{ij} = \left(w_{ij}/\mathbf{W}_j\right)^{1+\eta}$, the only way that $s'_{ij} > s_{ij}$ while $w'_{ij} < w_{ij}$ is if the market wage decreased: $\mathbf{W}'_j < \mathbf{W}_j$.
- For firm k, arguing the opposite implies $\mathbf{W}'_j > \mathbf{W}_j$. This is a contradiction: $\mathbf{W}_j$ can not have increased and decreased.

□

Lemma 2 - *Assume $z_{1j} > z_{2j}$, then merging firms satisfy the following properties :*

1. *In terms of wage changes:* $\Delta \log w_{1j} > \Delta \log w_{2j}$

- Since both firms' productivity is constant and both have the same markdown post-merger:

$$\Delta \log w_{1j} - \Delta \log w_{2j} = \underbrace{\log \mu\left(s_{2j}\right) - \log \mu\left(s_{1j}\right) > 0}_{\text{Since } z_{1j} > z_{2j} \text{then } \mu\left(s_{1j}\right) < \mu\left(s_{2j}\right)}$$

2. *The relative share of the most productive of the merging firms increases* $\widetilde{s}'_{1A} > \widetilde{s}_{1A}$.

   - Here we omit j subscripts for clarity. Since $\mu\left(s_1\right) < \mu\left(s_2\right)$, then

$$\frac{w'_1}{w_1} > \frac{w'_2}{w_2} \quad \Longrightarrow \quad \frac{w'_2}{w'_1} < \frac{w_2}{w_1}$$

   - Manipulating both sides

$$\frac{1}{1+\left(\frac{w'_2}{w'_1}\right)^{1+\eta}} > \frac{1}{1+\left(\frac{w_2}{w_1}\right)^{1+\eta}}$$

$$\frac{w_1'^{1+\eta}}{w_1'^{1+\eta}+w_2'^{1+\eta}} > \frac{w_1^{1+\eta}}{w_1^{1+\eta}+w_2^{1+\eta}}$$

$$\left(\frac{w'_1}{\mathbf{W}_A}\right)^{1+\eta} > \left(\frac{w_1}{\mathbf{W}_A}\right)^{1+\eta}$$

$$\widetilde{s}'_{1A} > \widetilde{s}_{1A}$$

□

Lemma 3 - *For non-merging firms, if* $s'_{ij} > s_{ij}$ *then* $n'_{ij} > n_{ij}$.

- **Proof**: Firm profit is

$$\pi_{ij} = z_{ij}n_{ij} - w_{ij}n_{ij} = z_{ij}n_{ij} - \left(n_{ij}^{\frac{1}{\eta}}\mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}}\mathrm{X}\right)n_{ij}$$

- First order condition for non-merging firms

$$
\begin{aligned}
z_{ij} - w_{ij} &= \left(\frac{1}{\eta} n_{ij}^{\frac{1}{\eta}-1} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} X + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) n_{ij}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}-1} X \frac{\partial \mathbf{N}_j}{\partial n_{ij}}\right) n_{ij} \\
z_{ij} - w_{ij} &= \frac{1}{\eta} w_{ij} - \left(\frac{1}{\theta} - \frac{1}{\eta}\right) n_{ij}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} X \left(\frac{\partial \mathbf{N}_j}{\partial n_{ij}} \frac{n_{ij}}{\mathbf{N}_j}\right) \\
z_{ij} - \left(\frac{\eta+1}{\eta}\right) w_{ij} &= \left(\frac{1}{\theta} - \frac{1}{\eta}\right) \left(n_{ij}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} X\right) s_{ij} \\
\frac{\eta}{\eta+1} z_{ij} - w_{ij} &= \frac{\eta}{\eta+1} \left(\frac{1}{\theta} - \frac{1}{\eta}\right) n_{ij}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} X s_{ij}
\end{aligned}
$$

- Now use the fact that $s_{ij} = \left(n_{ij}/\mathbf{N}_j\right)^{\frac{\eta+1}{\eta}}$, which implied that $\mathbf{N}_j = n_{ij} s_{ij}^{-\frac{\eta}{\eta+1}}$.

$$
\begin{aligned}
\frac{\eta}{\eta+1} z_{ij} - w_{ij} &= \frac{\eta}{\eta+1} \left(\frac{1}{\theta} - \frac{1}{\eta}\right) n_{ij}^{\frac{1}{\eta}} \left(n_{ij} s_{ij}^{-\frac{\eta}{\eta+1}}\right)^{\frac{1}{\theta}-\frac{1}{\eta}} X s_{ij} \\
\frac{\eta}{\eta+1} z_{ij} - w_{ij} &= \frac{\eta}{\eta+1} \left(\frac{1}{\theta} - \frac{1}{\eta}\right) n_{ij}^{\frac{1}{\theta}} s_{ij}^{-\frac{\eta}{\eta+1}\left(\frac{1}{\theta}-\frac{1}{\eta}\right)+1} X \\
\left[\frac{\eta}{\eta+1} z_{ij} - w_{ij}\right] s_{ij}^{\frac{\eta}{\eta+1}\left(\frac{1}{\theta}-\frac{1}{\eta}\right)-1} &= \frac{\eta}{\eta+1} \left(\frac{1}{\theta} - \frac{1}{\eta}\right) X n_{ij}^{\frac{1}{\theta}}
\end{aligned}
$$

- We can substitute in the wage given our closed form expression for $\mu\left(s_{ij}\right)$:

$$
\begin{aligned}
\left[\frac{\eta}{\eta+1} z_{ij} - \mu\left(s_{ij}\right) z_{ij}\right] s_{ij}^{\frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right)-1} &= \frac{\eta}{\eta+1} \left(\frac{\eta-\theta}{\theta\eta}\right) X n_{ij}^{\frac{1}{\theta}} \\
z_{ij} \left[\frac{\eta}{\eta+1} - \frac{\eta}{\eta+1} \frac{1}{1 + \frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right) s_{ij}}\right] s_{ij}^{\frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right)-1} &= \frac{\eta}{\eta+1} \left(\frac{\eta-\theta}{\theta\eta}\right) X n_{ij}^{\frac{1}{\theta}} \\
z_{ij} \left[1 - \frac{1}{1 + \frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right) s_{ij}}\right] s_{ij}^{\frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right)-1} &= \left(\frac{\eta-\theta}{\theta\eta}\right) X n_{ij}^{\frac{1}{\theta}} \\
z_{ij} \left[\frac{\frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right) s_{ij}}{1 + \frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right) s_{ij}}\right] s_{ij}^{\frac{\eta}{\eta+1}\left(\frac{\eta-\theta}{\theta\eta}\right)-1} &= \left(\frac{\eta-\theta}{\theta\eta}\right) X n_{ij}^{\frac{1}{\theta}} \qquad (\#)
\end{aligned}
$$

- **Sufficient** - *If the LHS is* <u>*increasing*</u> *in* s_{ij}*, then the RHS is increasing in* n_{ij}*. Since we have already shown that non-merging firms' shares increase, then* n_{ij} *increases.*

- Note that $z_{ij} > 0$, and the remainder of the LHS takes the form of a function $f(s) = \frac{as}{1+as} s^{a-1}$, $a > 0$.

- Then

$$f'(s) = \frac{as^{a-1}}{1+as} \left[\frac{1}{1+as} + (a-1) \right]$$

- The first term is positive, and the second term implies that $f'(s) > 0$, if $s(1-a) < 1$.

- Sufficient conditions are $a > 0$, and $s \in [0,1]$. Since s_{ij} is a share, then $s_{ij} \in [0,1]$. And $a = \frac{\eta}{\eta+1} \left(\frac{\eta-\theta}{\theta\eta} \right) > 0$, since $\eta > \theta$.

□

B Illustrative numerical example of mergers

To provide intuition for how the model works, we first explore the implications of mergers in a stylized economy with identical, symmetric firms. We consider an economy with the same parameters as Table 1, except we remove all firm heterogeneity, i.e., $z_{ij} = \bar{z}\ \forall ij$. Markets still differ with respect to the number of firms-per-market, M_j. We then merge two firms in each market.

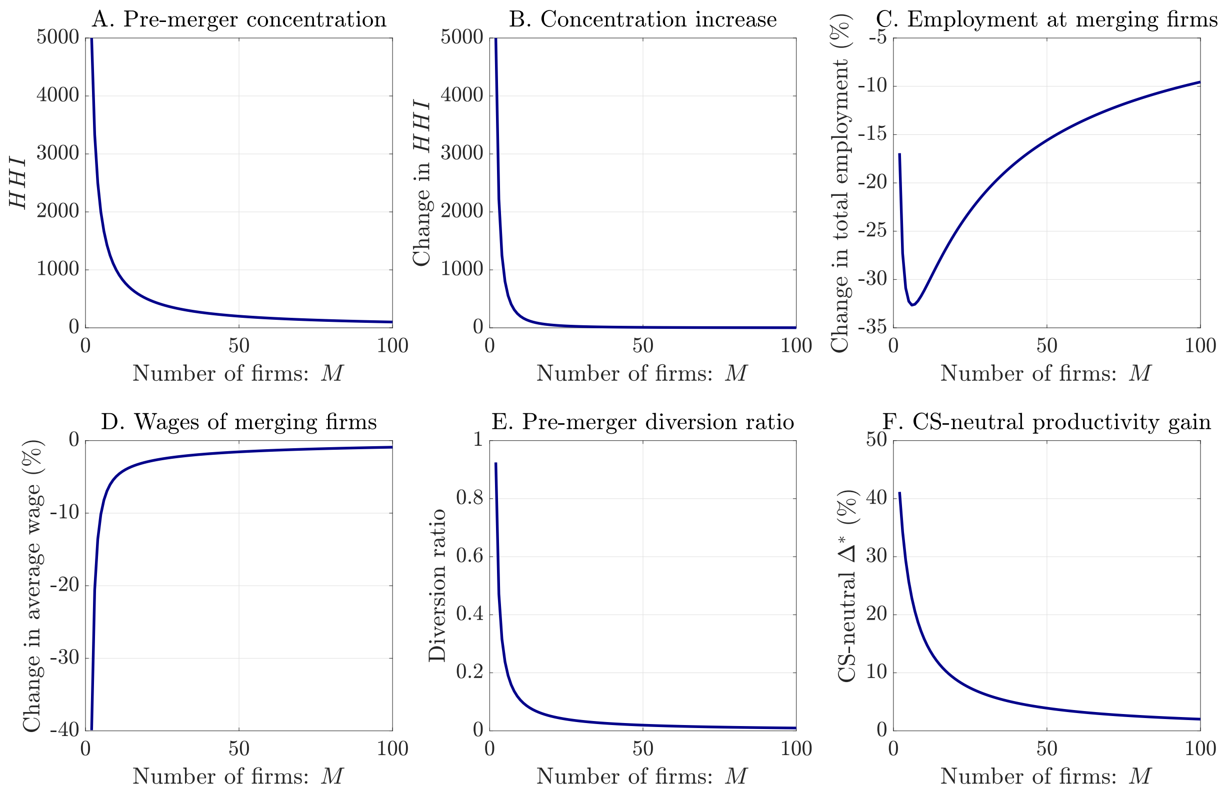

Figure 4: Effects of symmetric mergers by firms-per-market M_j.

Figure 4 shows how, in this simple example, the negative effects of a merger are much more pronounced in markets with initially fewer firms. We plot the effects on concentration, employment, wages, the diversion ratio, and the worker surplus neutral productivity Δ^* defined in *Proposition 2*. Panel A shows that for $M_j = 2$ concentration initially begins with a payroll Herfindahl of $HHI_j = 5,000$, corresponding to two identical and symmetric firms.[27] Panel B shows that after the two symmetric firms merge, the Herfindahl reaches its maximum value of $HHI'_j = 10,000$, implying a change in the Herfindahl of $\Delta HHI_j = HHI'_j - HHI_j = 5000$. Panel C shows that this merger generates a 17 percent reduction in employment at the merg-

[27] With two symmetric firms, $HHI_j = [(0.50 \times 100)^2 + (0.50 \times 100)^2 = 5,000$.

ing firms. In restricting quantities in this way, given the entity's new, higher level of market power, the monopsonist can *lower* wages (Panel D). Panel E plots the diversion ratio (defined to be $-\frac{\partial n_{2j}}{\partial w_{1j}} / \frac{\partial n_{1j}}{\partial w_{1j}}$) and shows that it attains its highest value of 0.8 when duopsonists merge into a pure monopsonist.[28] A diversion ratio of 0.8 implies that for a hypothetical, partial equilibrium, wage hike sufficient to deliver one new worker to plant i, 0.8 workers leave plant i'.

Panel F plots the post-merger *required efficiency gain* (REG), Δ^*, required to deliver worker surplus neutrality (see Proposition 2). Following Proposition 2, we augment the merged firm's objective function with merger efficiency gains, Δ^*, so that they solve

$$\pi_{ij} = \max_{n_{ij}, n_{i'j}} \; z_{ij} e^{\Delta^*} n_{ij} - w_{ij} n_{ij} + z_{i'j} e^{\Delta^*} n_{i'j} - w_{i'j} n_{i'j}, \tag{17}$$

subject to the labor supply curves for both i and i', given by (5). By definition of Δ^*, the resulting employment and wage decisions of the newly merged firm yield constant sectoral wage and employment indexes, thus achieving worker surplus neutrality.

Panel F shows that when duopsonists merge into a pure monopsonist, the merge must yield efficiency gains of 40 percent in order for worker surplus neutrality. For markets with more than 35 identical firms, the REG for worker surplus neutrality lies below 5 percent, a commonly assumed value of merger efficiency gains (Farrell and Shapiro, 2010).

While Figure 4 is a useful illustrative exercise, it is insufficient for merger analysis. In reality, firms within markets are not symmetric. Markets with 35 firms, like in the above example, may have three or four highly productive and relatively large firms while the remaining firms are small. In practice, the market power accruing to these firms will be much more like that accruing to a firm in a market with five or six identically sized firms. A key contribution of our framework is to account for the across-market heterogeneity in the distribution of firms. Therefore, we next turn to our quantitative model. Consistent with the data, in the quantitative model the average market has more than 100 firms, but the average HHI is $1,100$. The latter is consistent with an HHI that would be observed in a market with around 10 symmetric firms. Comparing markets with 100 or 10 symmetric firms in Figure 4, required efficiency gains for worker surplus neutrality are enormously different.

[28] Our model yields a convenient formula for diversion ratios as a function of parameters, shares and initial employment levels:

$$\text{Diversion ratio} = -\frac{\partial n_{2j}}{\partial w_{1j}} \left[\frac{\partial n_{1j}}{\partial w_{1j}}\right]^{-1} = \frac{(\eta - \theta)\, s_{1j}}{[\eta - (\eta - \theta)\, s_{1j}]} \left(\frac{n_{2j}}{n_{1j}}\right)$$

.

C Distribution of required efficiency gains

In this section, we study the distribution of required efficiency gains for worker surplus neutrality. Similar to Section 8, we simulate a representative set of mergers in the U.S. following the procedure outlined below:

1. Draw $N = 200,000$ markets from the empirical distribution of markets in the United States. This includes the number of firms, distributed $G(M_j)$, and the productivity of firms within each market, distributed $F(z_{ij})$.
2. Randomly choose two candidate merging firms i and i'. Only consummate the merger if i and i''s average pre-merger employment is greater than $\tilde{n} = 46$. Imposing this size cutoff allows us to match the observed median merger size in Arnold (2020)'s representative sample of mergers in the U.S. (see Section 6 for additional details).[29]
3. Compute the REG for worker surplus neutrality, Δ^*, defined by Proposition 2.
4. Index each REG, Δ^*, by its simulation number $n \in \{1, \ldots, N\}$ and store the vector $\{\Delta_n^*\}_{n=1}^N$.
5. Compute moments of the distribution of REGs, $\{\Delta_n^*\}_{n=1}^N$.

Figure 5 reports various moments of the distribution of REGs, $\{\Delta_n^*\}_{n=1}^N$.[30] Panel A reports the 20^{th} percentile of the REG distribution in each $\{HHI_j, \Delta HHI_j\}$ bin. Panel B reports the median value of the REG distribution in each $\{HHI_j, \Delta HHI_j\}$ bin.

To interpret Figure 5, consider the bottom left most cell of Panel A which corresponds to mergers in markets where $HHI_j \in [0, 500)$ and $\Delta HHI_j \in [0, 50)$. Within that cell, we have thousands of simulated mergers according to the procedure outlined above. The 20th percentile of the distribution of Δ_n^* within that cell is a 0.01 percent productivity gain. This can be interpreted in two ways. First, if presented with a merger with $HHI_j \in [0, 500)$ and $\Delta HHI_j \in [0, 50)$, and merger efficiency gains are assumed to be 0.01 percent, then 80 percent of those mergers would yield worker surplus neutrality, or better. Second, if the regulator believed efficiency gains were near-zero and approved all mergers in which $HHI_j \in [0, 500)$ and $\Delta HHI_j \in [0, 50)$, the regulator would only mergers that harm workers 20 percent of the time.

Panel A of Figure 5 shows that—holding initial concentration fixed—the 20th percentile of REGs monotonically increases in ΔHHI_j. If merger efficiency gains are assumed to be 5 percent, *less than* 20 percent of simulated mergers where $\Delta HHI_j > 250$ generate a worker surplus gain.

[29] Note that the lower employment threshold of $\tilde{n} = 46$ in this section is estimated so that the median pre-merger employment of the merging firms is 116.

[30] Before moving on to the next figure, a notable feature of Figure 5 and subsequent figures, is the missing cell values. Mathematically, it is impossible to have certain combinations of HHI and ΔHHI and certain target/acquirer shares. To see this, notice that each component of $\Delta HHI_j = (s_{ij} + s_{i'j})^2 - s_{ij}^2 - s_{i'j}^2$ can be bound by the initial HHI. Likewise shares are bound and must sum to less than one, $s_{i'j} + s_{ij} \leq 1$. In competitive markets where $HHI \in [0, 500)$, no merger between firms can produce a change in HHI above a value of 50.

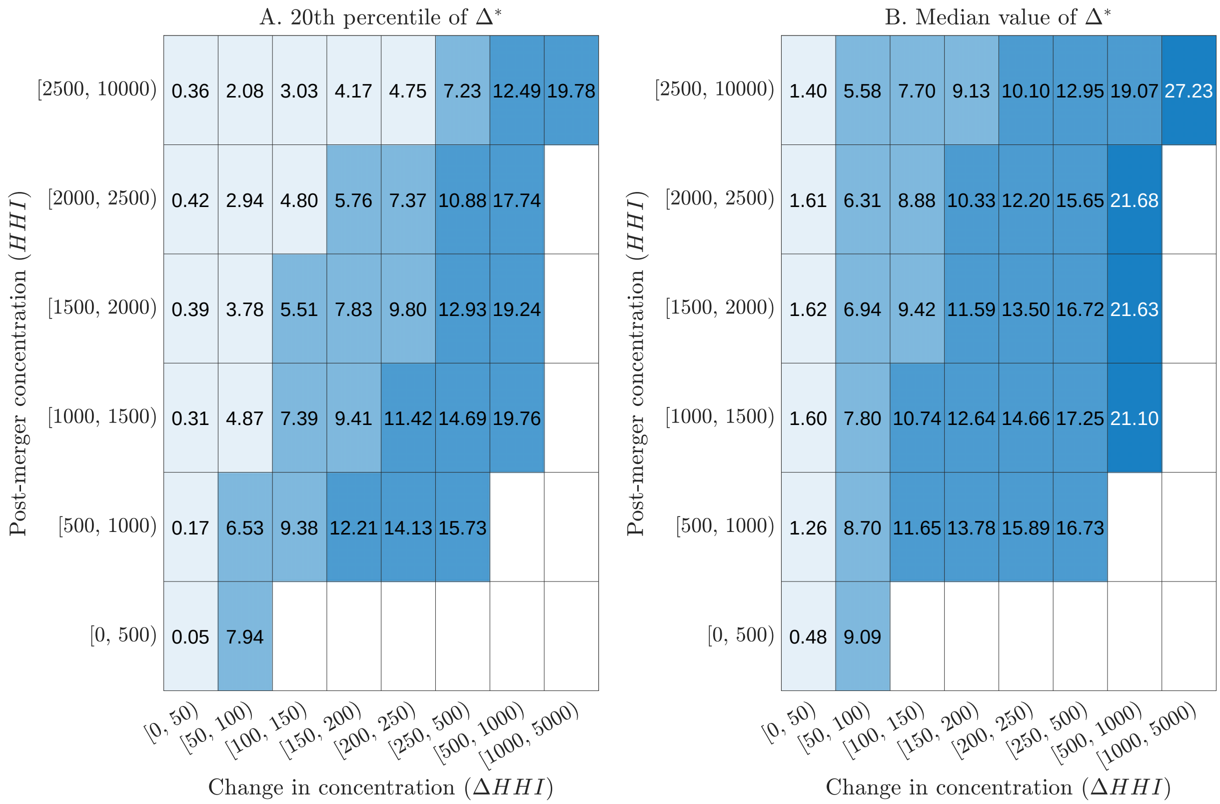

Figure 5: Percentiles of the distribution of worker surplus neutral efficiency gains $\{\Delta_n^*\}$

In other words, if merger efficiency gains are assumed to be 5 percent, *more than* 80 percent of simulated mergers where $\Delta HHI_j > 250$ generate a worker surplus loss. If merger efficiency gains are assumed to be 3 percent, *more than* 80 percent of simulated mergers where $\Delta HHI_j > 100$ generate a worker surplus loss.

Panel B of Figure 5 reports the 50th percentile of required efficiency gains for worker surplus neutrality, $\{\Delta_n^*\}_{n=1}^N$, conditional on HHI_j and ΔHHI_j. Many of the qualitative and quantitative features of Panel B mirror Panel A. If merger efficiency gains are assumed to be 5 percent, *more than* 50 percent of simulated mergers where $\Delta HHI_j > 50$ generate a worker surplus loss.

We repeat this exercise and compute the distribution of required efficiency gains for worker surplus neutrality stratified by the merging firms' initial payroll shares of the local labor market. Figure 6A plots the 20th percentile of the distribution of required efficiency gains $\{\Delta_n^*\}$ for worker surplus neutrality stratified by the merging firms' initial payroll shares of the local labor market. If efficiency gains are 5 percent, then less than 20 percent of mergers yield worker surplus gains in which the smaller merging firm's local payroll share is greater 5 percent. In other words, even if we assume a standard efficiency gain of 5 percent, more than 80 percent of mergers in which the smaller firm's payroll share of the local labor market is greater than 5

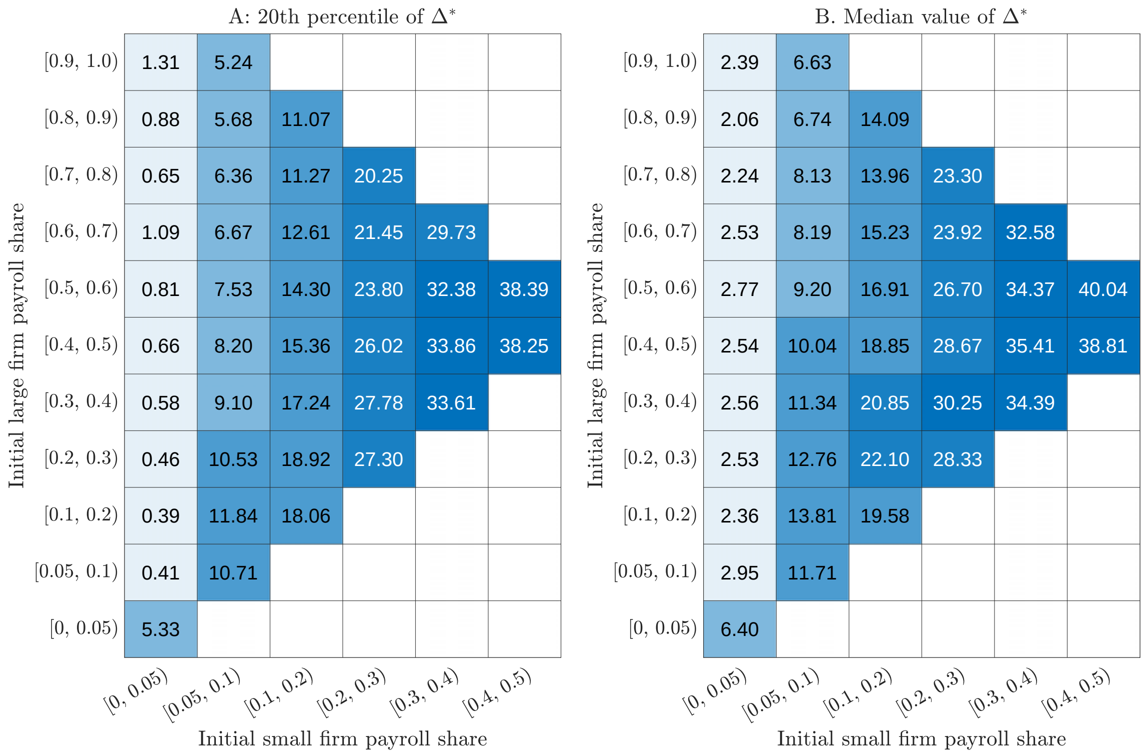

Figure 6: Percentiles of the distribution of required efficiency gains $\{\Delta_n^*\}$ for worker surplus neutrality - By shares

percent yield worker surplus losses. Likewise, Figure 6B reports the 50th percentile percentile of the distribution of required efficiency gains. Even if efficiency gains are 6 percent (larger than the standard assumption), the majority of mergers yield worker surplus losses if the smaller merging firm's local payroll share is greater 5 percent.

Figure 7 plots the fraction of mergers yielding worker surplus gains for efficiency gains of 5 percent (Panel A) and 10 percent (Panel B). Assuming a standard 5 percent efficiency gain, we find that if the smaller merging firm's local labor share is greater than 5 percent, less than 13 percent of all simulated mergers generate a worker surplus gain.

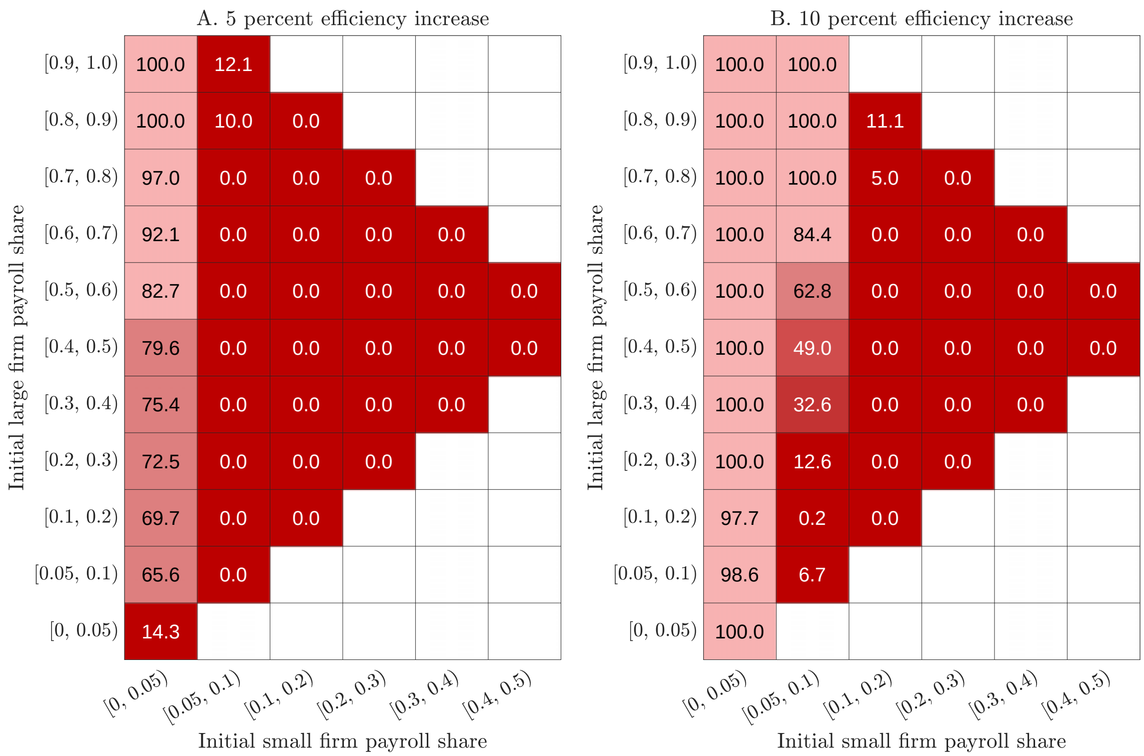

Figure 7: Fraction of mergers yielding worker surplus gains for efficiency gain $\Delta \in \{5\%, 10\%\}$ - By shares

D Uni-dimensional merger guidelines

Next, we evaluate uni-dimensional merger guidelines based on HHIs alone or ΔHHI's alone and applied to our simulated $N = 200,000$ representative mergers.

Figure 8 plots the expected change in the market-level wage index under the assumption of various uni-dimensional merger guidelines. The x-axis varies the assumed level of efficiency gains from 0 to 15 percent. Each line corresponds to a different uni-dimensional merger guideline.

Figure 8A shows that under an assumed efficiency gain of 0 percent (light-blue, triangles), allowing mergers yields an average market-level wage reduction of -2.4 percent. Merging firms cut employment to lower wages, and thus the mergers are not worker surplus neutral. Keeping the assumed efficiency gain at 0 percent and moving up to the next darkest line (circles), we see that a policy in which all mergers are blocked in extremely concentrated markets $(HHI_j > 5,000)$ mitigates the average market-level wage loss to -1.7 percent. The expected drop in the wage index is mitigated because mergers with the largest negative impact on wages are now blocked.

If a regulator aims to have an expected zero decline in wages, and assumes a 5 percent efficiency gain, then Figure 8A shows that a policy of blocking mergers with an $HHI > 1,500$ is necessary.

Figure 8B yields a similar set of results for ΔHHI thresholds. If a regulator aims to have an expected zero decline in wages, and assumes a 5 percent efficiency gain, then Figure 8A shows that a policy of blocking mergers with an $\Delta HHI > 300$ would need to be implemented.

D.1 Confidence levels

Table 4 reports the necessary uni-dimensional HHI and ΔHHI thresholds necessary to guarantee a certain fraction of approved mergers yield a worker surplus gain.

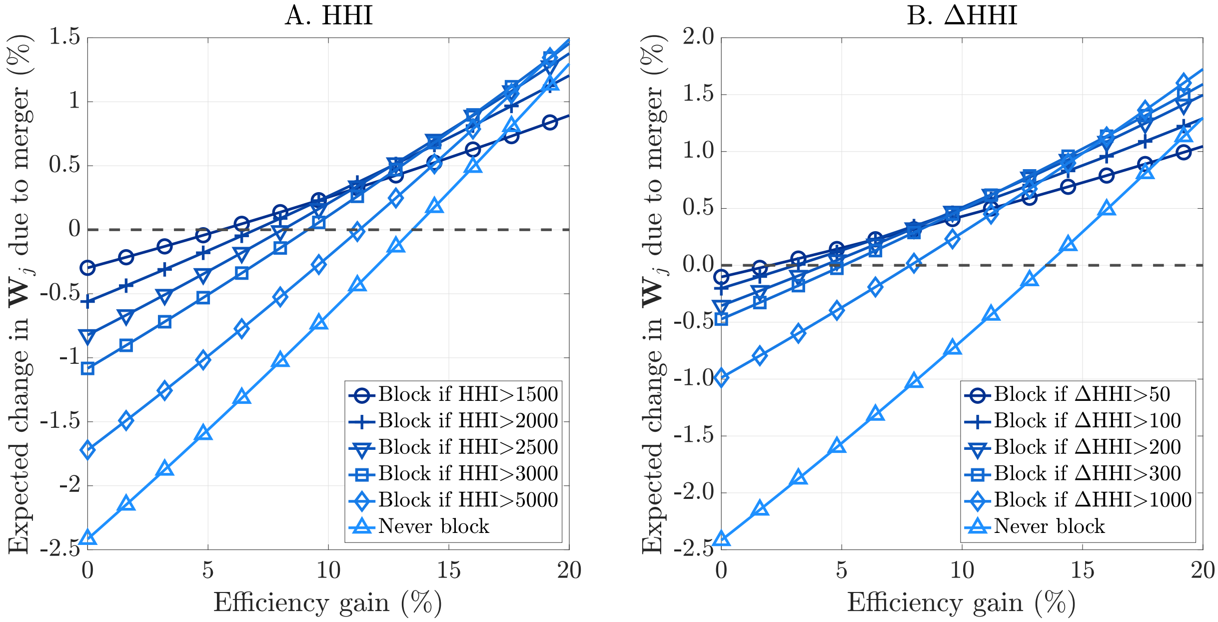

Figure 8: Expected change in market wage under alternative merger policies

Notes: Figures plots the Expected change in market-level wage $\mathbf{W}_j$ post-merger as a function of the assumed efficiency gain and merger policy. Efficiency gain on the x-axis is applied to both merging plants in all cases.

	Probability of WS gain				
	30%	35%	40%	45%	50%
HHI					
1% Efficiency gain	1694	1313	1049	863	726
2% Efficiency gain	3524	2301	1734	1372	1107
3% Efficiency gain	9990	4150	2643	1959	1548
4% Efficiency gain	10000	9990	4316	2800	2086
5% Efficiency gain	10000	10000	9990	4316	2878
Δ HHI					
1% Efficiency gain	140	80	55	40	30
2% Efficiency gain	751	305	170	105	75
3% Efficiency gain	4850	1066	440	240	150
4% Efficiency gain	5000	4645	1156	511	285
5% Efficiency gain	5000	5000	4209	1176	556

Table 4: Uni-dimensional HHI and ΔHHI cutoffs necessary so that $\{30\%, 35\%, 40\%, 45\%, 50\%\}$ of mergers yield a worker surplus gain.

E Output-based merger guidelines

We provide output-based guidance on mergers in Figure 9. In this section, we simulate a random set of mergers from all pairwise combinations of firms, and – unlike the main text – we consummate all mergers regardless of firm size:

1. Draw $N = 200,000$ markets from the empirical distribution of markets in the United States. This includes the number of firms, distributed $G(M_j)$, and the productivity of firms within each market, distributed $F(z_{ij})$.
2. Randomly choose two candidate merging firms i and i'. In this section – unlike the main text – we consummate all mergers regardless of employment.
3. Compute the probability of an output loss from the merger, and if the merger results in a loss, compute the magnitude of the output.

Panel A shows the fraction of simulated mergers that yield an output loss *at the market level* for a given level of efficiency gain Δ in equation (17). When the merging firms' combined pre-merger payroll shares are less than 20 percent and the efficiency gains from the merger are assumed to be 5 percent, all simulated mergers generate output gains. That is, a 5 percent efficiency gain more than offsets the output losses due to the merging firms contracting employment.

Panel B shows the median output loss conditional on the merger generating an output loss. If the efficiency gain from a merger is 5 percent, the median total market-level output loss from a merger is upwards of 2 percent whenever the combined merging firms' payroll shares exceed 60 percent.

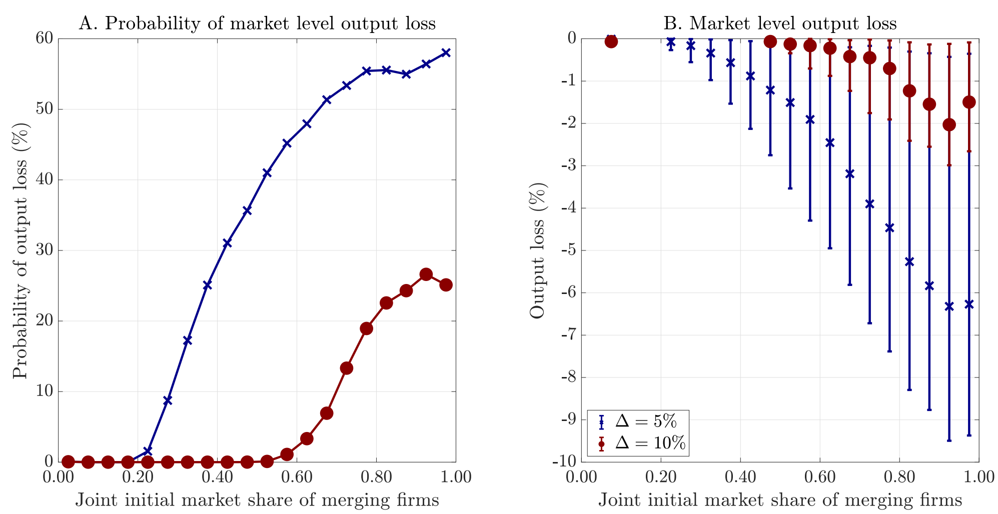

Figure 9: Output losses for a merger efficiency gain of $\Delta^+ \in \{5\%, 10\%\}$

F Employment-based merger guidelines

Following the same procedure in Appendix E, Figure 10A plots the probability that a merger generates an employment loss, and if there is an employment loss, Figure 10B computes the magnitude of that loss. Since productivity gains increase output, conditional on employment, employment losses are larger and more significant than output losses, even for smaller mergers. When merging firms' payroll shares are above 20 percent, even if efficiency gains are 5 percent, a majority of our simulated mergers generate employment losses at the market level (i.e. taking into account reallocation of workers to other firms in the market). Panel B shows the median employment loss at the market level, conditional on the merger generating an employment loss. If efficiency gains are 5 percent, the median employment loss is upwards of 1 percent whenever the combined merging firms' payroll shares exceed 30 percent. Greater efficiency gains from mergers are required to mitigate employment losses than output losses.

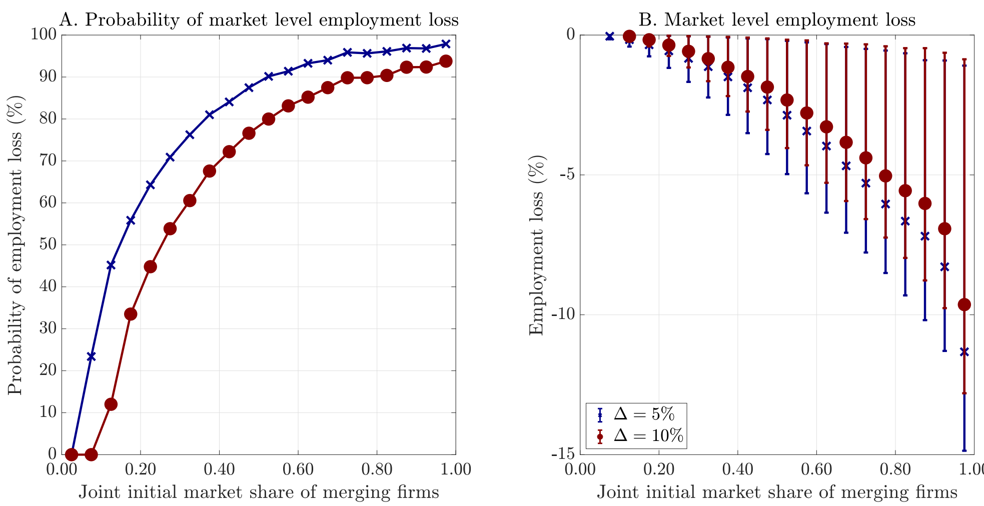

Figure 10: Employment losses for a merger efficiency gain of $\Delta^+ \in \{5\%, 10\%\}$

G Welfare approximation

Table 5 reports the welfare implications of various merger guidelines. The welfare metrics are in 2014 dollars and are derived as follows. We assume that mergers occur in a positive measure $\bar{J}$ of identical markets, where we organize market indexes such that $j \in [0, \bar{J}]$ markets are involved in the merger. We use a first-order Taylor expansion to approximate the welfare effects:

$$U(\mathbf{C},\mathbf{N}) \approx U(\mathbf{C}_0,\mathbf{N}_0) + \left[\frac{d}{dC}U(\mathbf{C},\mathbf{N})\frac{d\mathbf{C}}{d\mathbf{WN}}\frac{d\mathbf{WN}}{d\int_0^{\bar{J}}\mathbf{W}_j\mathbf{N}_j dj}\right]\Big|_{\mathbf{C}=\mathbf{C}_0,\mathbf{N}=\mathbf{N}_0} \underbrace{d\int_0^{\bar{J}}\mathbf{W}_j\mathbf{N}_j dj}_{\text{merger induced}} + \left[\frac{d}{d\mathbf{N}}U(\mathbf{C},\mathbf{N})\frac{d\mathbf{N}}{d\int_0^{\bar{J}}\mathbf{N}_j^{\frac{\theta+1}{\theta}}dj}\right]\Big|_{\mathbf{C}=\mathbf{C}_0,\mathbf{N}=\mathbf{N}_0} \underbrace{d\int_0^{\bar{J}}\mathbf{N}_j^{\frac{\theta+1}{\theta}}dj}_{\text{merger induced}}$$

The household budget constraint is given by

$$\mathbf{C} = \int_0^1 \mathbf{W}_j\mathbf{N}_j dj + \Pi$$

Thus, we can compute

$$\frac{d\mathbf{C}}{d\mathbf{WN}} = 1, \qquad \frac{d\mathbf{WN}}{d\int_0^{\bar{J}}\mathbf{W}_j\mathbf{N}_j dj} = 1.$$

Next, we use a first-order Taylor approximation to approximate aggregate labor supply $\mathbf{N}$:

$$\mathbf{N} = \left[\int_0^1 \mathbf{N}_j^{\frac{\theta+1}{\theta}}dj\right]^{\frac{\theta}{\theta+1}} \approx \mathbf{N}_0 + \frac{\theta}{\theta+1}\mathbf{N}_0^{-\frac{1}{\theta}}\left(\int_0^1\left(\mathbf{N}_j^{\frac{\theta+1}{\theta}} - \mathbf{N}_j^{\frac{\theta+1}{\theta}}\right)dj\right).$$

Thus, we can compute the derivative of $\mathbf{N}$ with respect to the contribution of market j to $\mathbf{N}$:

$$\frac{d\mathbf{N}}{d\int_0^{\bar{J}}\mathbf{N}_j^{\frac{\theta+1}{\theta}}dj} = \frac{\theta}{\theta+1}\mathbf{N}_0^{-\frac{1}{\theta}}.$$

With the GHH preferences in the main text, the marginal utility of consumption and marginal disutility of labor evaluated at the pre-merger levels of $\mathbf{C}$ and $\mathbf{N}$ are

$$\frac{d}{d\mathbf{C}}U(\mathbf{C},\mathbf{N})\Big|_{\mathbf{C}=\mathbf{C}_0,\mathbf{N}=\mathbf{N}_0} = 1, \qquad \frac{d}{d\mathbf{N}}U(\mathbf{C},\mathbf{N})\Big|_{\mathbf{C}=\mathbf{C}_0,\mathbf{N}=\mathbf{N}_0} = -\bar{\varphi}^{-\frac{1}{\psi}}\mathbf{N}_0^{\frac{1}{\psi}}.$$

Then, welfare following a merger in a market with measure $[0, \bar{J}]$ is approximated by

$$U(\mathbf{C},\mathbf{N}) \approx U(\mathbf{C}_0,\mathbf{N}_0) + d\int_0^{\bar{J}}\mathbf{W}_j\mathbf{N}_j dj - \bar{\varphi}^{-\frac{1}{\psi}}\frac{\theta}{\theta+1}\mathbf{N}_0^{\frac{1}{\psi}-\frac{1}{\theta}} d\int_0^{\bar{J}}\mathbf{N}_j^{\frac{\theta+1}{\theta}}dj. \tag{18}$$

	A. 1982 guidelines		B. 2010 guidelines	
DOJ/FTC market classification	Moderate	High	Moderate	High
Threshold (HHI, ΔHHI)	(1000, 100)	(1800, 100)	(1500, 100)	(2500, 200)
	(1)	(2)	(3)	(4)
I. Average REG				
Permitted mergers	3.50	4.68	4.16	5.96
Blocked mergers	18.73	19.97	19.35	22.88
II. Change in average welfare assuming 1 percent efficiency gain ($)				
Permitted mergers	-77,811	-129,352	-106,333	-188,107
Blocked mergers	-907,052	-993,613	-949,747	-1,191,513
III. Change in average welfare assuming 2 percent efficiency gain ($)				
Permitted mergers	-41,690	-92,925	-70,057	-150,961
Blocked mergers	-862,192	-947,482	-904,247	-1,143,308
IV. Change in average welfare assuming 3 percent efficiency gain ($)				
Permitted mergers	-4,963	-55,899	-33,180	-113,226
Blocked mergers	-816,744	-900,754	-858,155	-1,094,483
V. Change in average welfare assuming 4 percent efficiency gain ($)				
Permitted mergers	32,375	-18,271	4,305	-74,898
Blocked mergers	-770,700	-853,421	-811,465	-1,045,030
VI. Change in average welfare assuming 5 percent efficiency gain ($)				
Permitted mergers	70,327	19,963	42,400	-35,972
Blocked mergers	-724,053	-805,476	-764,167	-994,940

Table 5: Average worker welfare change per-market, in 2014 dollars.

Notes. Welfare metrics computed using equation (18) and expressed in 2014 dollars, and enter in Panels II through VI. is an average welfare change per-market. Merger simulation designed to match a representative set of firms based on Arnold (2020); see text for details. Panel A applies the 1982 guidelines. In Column (1), all mergers with post-merger concentration/change in concentration above ($HHI = 1000, \Delta HHI = 100$) are blocked. In Column (2), all mergers with post-merger concentration/change in concentration above ($HHI = 1800, \Delta HHI = 100$) are blocked. Panel B applies 2010 guidelines. In Column (3), all mergers with post-merger concentration/change in concentration above ($HHI = 1500, \Delta HHI = 100$) are blocked. In Column (2), all mergers with post-merger concentration/change in concentration above ($HHI = 2500, \Delta HHI = 200$) are blocked. Panel I reports the average required efficiency gain for worker surplus neutrality. Panels II through VI report average change in welfare (in dollars) when the merger generates an efficiency gain of $\{1\%, 2\%, 3\%, 4\%, 5\%\}$ at both plants, as defined by equation (17).

H Type I and type II error rates

Table 6 assesses the HHI and ΔHHI cutoffs from the merger guidelines in DOJ and FTC (1982) and DOJ and FTC (2010) by comparing type I and II error rates. A type I error occurs if a merger that generates worker surplus gains is blocked. A type II error occurs if a merger that generates a worker surplus loss is not blocked. A stringent merger review guideline that blocks many mergers generates a large type I error but a small type II error; that is, the probability that a permitted merger yields worker surplus losses is small, but the probability that a blocked merger would have yielded worker surplus gains is large. A less stringent guideline yields low type I error rates but high type II error rates; that is, the probability of blocking a merger that would have generated worker surplus gains is low, but the probability of not blocking a merger that yields worker surplus losses is high.

For example, column (2) applies the threshold from DOJ and FTC (1982) that blocks mergers that generate post-merger HHIs above 1800 and raise the HHI by more than 100. Under the standard assumed efficiency gain of 5 percent, there is a 4.88 percent probability of blocking a merger that would generate worker surplus gains and a 31.06 percent probability of permitting a merger that yields worker surplus losses.

We can compare this to column (4), which applies the less stringent threshold from DOJ and FTC (2010) that blocks mergers that generate post-merger HHIs above 2500 and raise the HHI by more than 200. Under that threshold, there is a 2.47 percent probability of blocking a merger that generates gains. However, the probability of letting through a merger that generates losses is 47.53 percent, eight percentage points higher than under the 1982 guidelines.

DOJ/FTC market classification Threshold (HHI, ΔHHI)	A. 1982 guidelines Moderate (1000, 100) (1)	 High (1800, 100) (2)	B. 2010 guidelines Moderate (1500, 100) (3)	 High (2500, 200) (4)
I. Average REG				
Permitted mergers	3.50	4.68	4.16	5.96
Blocked mergers	18.73	19.97	19.35	22.88
II. Error rates assuming 1 percent efficiency gain (%)				
Probability that a blocked merger yields WS gain	0.04	0.04	0.04	0.00
Probability that a permitted merger yields WS loss	67.33	71.61	69.75	76.10
III. Error rates assuming 2 percent efficiency gain (%)				
Probability that a blocked merger yields WS gain	0.40	0.48	0.44	0.13
Probability that a permitted merger yields WS loss	54.47	60.44	57.84	66.51
IV. Error rates assuming 3 percent efficiency gain (%)				
Probability that a blocked merger yields WS gain	1.34	1.57	1.46	0.62
Probability that a permitted merger yields WS loss	45.07	52.24	49.13	59.20
V. Error rates assuming 4 percent efficiency gain (%)				
Probability that a blocked merger yields WS gain	2.72	3.07	2.94	1.37
Probability that a permitted merger yields WS loss	37.62	45.68	42.20	53.14
VI. Error rates assuming 5 percent efficiency gain (%)				
Probability that a blocked merger yields WS gain	4.59	4.88	4.86	2.47
Probability that a permitted merger yields WS loss	31.06	39.69	36.02	47.53

Table 6: Type I and Type II error rates.

Notes. The probability that a blocked merger yields worker surplus gains is computed as the fraction of blocked mergers that generate worker surplus gains. Similarly, the probability that a permitted merger yields worker surplus losses is computed as the fraction of permitted mergers that generate worker surplus losses. Merger simulation designed to match a representative set of firms based on Arnold (2020); see text for details. Panel A applies the 1982 guidelines. In Column (1), all mergers with post-merger concentration/change in concentration above ($HHI = 1000, \Delta HHI = 100$) are blocked. In Column (2), all mergers with post-merger concentration/change in concentration above ($HHI = 1800, \Delta HHI = 100$) are blocked. Panel B applies 2010 guidelines. In Column (3), all mergers with post-merger concentration/change in concentration above ($HHI = 1500, \Delta HHI = 100$) are blocked. In Column (2), all mergers with post-merger concentration/change in concentration above ($HHI = 2500, \Delta HHI = 200$) are blocked. Panel I reports the average required efficiency gain for worker surplus neutrality. Panels II through VI report the probability that a blocked merger yields worker surplus gains and the probability that a permitted merger yields worker surplus losses hen the merger generates an efficiency gain of $\{1\%, 2\%, 3\%, 4\%, 5\%\}$ *at both plants, as defined by equation (17).*