Merger Guidelines for the Labor Market*

David Berger, Thomas Hasenzagl, Kyle Herkenhoff, Simon Mongey, Eric A. Posner

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Abstract

While the labor market implications of mergers have historically been ignored, 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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*Berger: Duke University. Hasenzagl: University of Minnesota and Federal Reserve Bank of Minneapolis. Herkenhoff: University of Minnesota and Federal Reserve Bank of Minneapolis. Mongey: Federal Reserve Bank of Minneapolis and Kenneth C. Griffin Department of Economics, University of Chicago. Posner: University of Chicago Law School. We thank David Arnold, Dennis Carlton, Allan Collard-Wexler, Chris Conlon, Herbert Hovenkamp, Iona Marianescu, and James Schmitz Jr. for helpful comments. Herkenhoff and Mongey received support from NSF Award # 2214431 and Berger received support from NSF Award # 2214460. The views expressed in this study are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1 Introduction

There is a longstanding tradition within Industrial Organization of using simplified models to inform antitrust policy, with the Horizontal Merger Guidelines as a prime example. These guidelines have traditionally focused on product markets (e.g., Posner (2021) and Hovenkamp (2022)).[1] Recently, however, there's been an increasing recognition of imperfect competition in labor markets leading to substantial welfare losses (e.g., Azkarate-Askasua and Zerecero (2020), Brooks, Kaboski, Li, and Qian (2021), Jäger, Roth, Roussille, and Schoefer (2022), Lamadon, Mogstad, and Setzler (2022), Azar, Berry, and Marinescu (2022), Yeh, Macaluso, and Hershbein (2022), and Berger, Herkenhoff, and Mongey (2022) henceforth BHM). Consequently, the Department of Justice and Federal Trade Commission issued the 2023 Draft Merger Guidelines and codified their intent to address labor market power (see DOJ and FTC (2023) and discussion in Berger, Hasenzagl, Herkenhoff, Mongey, and Posner (2023)). In response to this development, our paper seeks to draw on this rich legacy by offering quantitative guidelines for potential antitrust scrutiny of labor markets.

We begin by incorporating multi-plant ownership into the micro-founded labor supply system developed by BHM in which jobs are differentiated and firms compete strategically. Mergers affect wages and markdowns solely through the presence of strategic interactions, and so strategic interactions are essential to match post-merger employment and wage losses documented in the data (Arnold (2020)). In non-strategic models of labor market power (e.g. Card, Cardoso, Heining, and Kline (2018), Lamadon, Mogstad, and Setzler (2022), Azar, Berry, and Marinescu (2022)), markdowns, wages, and employment are independent of multi-plant ownership, making it challenging for such environments to match post-merger employment and wage outcomes. In our framework, when firms own multiple plants, they internalize the way workers are diverted across plants and so they adjust their wage setting behavior when they control more of the local labor market. These strategic considerations also make the problem difficult to characterize (e.g., see Nocke and Schutz (2018) and Nocke and Whinston (2022)).

Relative to Nocke and Whinston (2022) and existing work on product markets, our paper makes several contributions: (i) We provide a complete theoretic characterization of the effects of mergers on labor markets, which, to our knowledge, is new to the literature.[2] (ii) We allow for decreasing or increasing returns to scale production functions, which are important arguments

[1] There is a small literature focusing on how to address buyer market power. See for instance, Gowrisankaran, Nevo, and Town (2015) and Ho and Lee (2017).

[2] 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 (2018) 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.

for efficiency gains from mergers (DOJ and FTC (2010) and DOJ and FTC (2023)).[3] Our baseline estimation yields decreasing returns, but we consider increasing returns to scale in Appendix L, giving rise to a notion of labor redundancy (pre-merger production can be achieved using fewer workers at a single consolidated plant). (iii) Our labor market effects of mergers in our model economy align in sign and magnitude with recent empirical evidence in Arnold (2020). (iv) 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. (v) Lastly, we derive a *Gross Downward Wage Pressure Index* (GDWPI) and show how this also relates to estimates of *Required Efficiency Gains* (REG), defined below. We believe these results are important for current and future revisions to labor market merger guidelines.

We begin by theoretically characterizing how mergers affect 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 assumption of Cournot competition in the labor market allows us to provide closed-form solutions for the common post-merger markdown and to characterize the effects of mergers on competitors and market structure. The quantitative model also 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 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 markets based on industry (3-digit North American Industry Classification System, *hereafter* NAICS3) and Commuting Zone (CZ) following BHM.[4] 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 quantitatively replicating 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

[3]See p. 29 of DOJ and FTC (2010), "For example, merger-generated efficiencies may enhance competition by permitting two ineffective competitors to form a more effective competitor, e.g., by combining complementary assets."

[4]Ideally, we would define markets based on occupations as in Azar, Marinescu, Steinbaum, and Taska (2020) and Berger, Herkenhoff, Kostøl, and Mongey (2023); however, no such data exists for the universe of workers in the U.S. There are subsamples of Census data in the ACS and Decennial Long Form with occupation codes, however, to compute concentration metrics, one requires occupation codes for all workers.

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 REG to achieve *worker surplus neutrality*. In other words, the REG is the post-merger productivity gain required to prevent worker harm. We define a merger as worker surplus neutral whenever the market-level wage index in which the merger occurs remains unchanged. This ensures that total wage bill payments are weakly greater than they were pre-merger. This welfare metric parallels the consumer surplus neutrality metric used in the product market by the DOJ and FTC (Pittman, 2007) and is conceptually consistent with the 2023 draft merger guidelines (Berger, Hasenzagl, Herkenhoff, Mongey, and Posner (2023)). In addition to the REG, we also report worker welfare in 2014 dollars in Appendix H.

Our first exercise demonstrates how our methods can be used in merger reviews by simulating the proposed 2021 Penguin Random House (PRH) and Simon & Schuster (SS) merger. In November of 2021, the Department of Justice sued to block the Penguin Random House and Simon & Schuster merger, citing harm to American best-selling authors (workers) due to monopsony concerns. In November 2022, this challenge resulted in the abandonment of the merger based on author (worker) harm. We find that in the absence of efficiency gains, the PRH and SS merger reduces market-level author wages by 5 percent. Moreover, 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.

Our second exercise measures the effects of applying the product market review guidelines from 1982 and 2010 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. These thresholds were maintained through revisions in 1984 and 1997, and then changed in 2010 The less stringent 2010 guidelines presume anticompetitive effects whenever post-merger HHIs exceed 2500 and ΔHHIs exceed 200. In 2023, the DOJ and FTC issued new draft guidelines, which changed the HHI thresholds back to the pre-2010 level. Because these draft guidelines have not yet been finalized, we will refer to the 1982 guidelines.

We apply the 1982 and 2010 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)[5] 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 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 before the merger. This means that under the standard "ad-hoc" efficiency gain of 5 percent (see e.g., Ivaldi and Verboven (2005) and discussion of this assumption in Bonnet and Schain (2017) and Bonnet and Schain (2020)), permitted mergers do not harm workers.[6] 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. In this case, if efficiency gains are 5 percent, permitted mergers yield worker surplus losses and 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.

What drives the stringency of merger review guidelines for the labor market? Firm market power in our framework results 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 Edmond, Midrigan, and Xu, 2018), it is arguably more costly for people to change employers than to switch products. Low labor supply elasticities imply significant wage markdowns and increase the likelihood of worker harm after a merger.[7]

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 be offset by efficiency gains from the merger. We measure downward wage pressure using a Gross

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

[6]Note that while many practitioners assume a 5% merger efficiency gain, there are very few studies that corroborate such large gains. Recent studies on administrative data suggest zero, or even negative, efficiency gains, e.g. Blonigen and Pierce (2016).

[7]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. Related work by Yeh, Macaluso, and Hershbein (2022) estimate similar magnitude markdowns in U.S. manufacturing.

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.

Our paper stops short of computing the optimal policy – such an exercise requires information not available publicly, including merger review costs, and it also requires a stance on the "objective function" of the agencies as a whole. However, 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 less risk-averse or resource-poor regulator would only want to review a small number of mergers. Given an assumed efficiency gain, that regulator may choose a concentration threshold for merger review above which they expect only 20 percent of mergers to yield worker surplus gains. A more risk-averse or resource-rich regulator would want to review many mergers, hence setting lower concentration cut-offs for merger review. Our framework can be used to compute such thresholds in future work.

Based on historic precedent, we treat product market effects of mergers as "out of market effects" when evaluating worker harm (e.g. Hemphill and Rose, 2018). We hold product prices fixed and ask whether workers are harmed solely via the effect of the merger on the labor market. The 2023 Draft Merger Guidelines codify this assumption in Guideline 11 (DOJ and FTC (2023)). Thus, our framework can be applied by the agencies as an initial screen of any merger in which basic information on local labor market payroll and employment is known. While outside the scope of the present paper, our framework can be modified to incorporate monopolistic pricing or richer theories of variable markups (see Deb, Eeckhout, Patel, and Warren, 2022, for such a modification of our framework) and discussion in Appendix K.

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, 2018; 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 results with the product market (Nocke and Schutz, 2018), 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. Both papers translate 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.[8] 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 available 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

[8]Other recent work evaluating antitrust claims in labor markets include: Hemphill and Rose (2018), Hovenkamp (2022), Alexander and Salop (2023), and Masur and Posner (2022).

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.).[9] Recent work by Jarosch, Nimcsik, and Sorkin (2019) also studies the wage effects of merging the top two largest firms in Austrian labor markets. Their innovative framework features large firms in a search and matching setting. However, their framework is partial equilibrium – contact rates, firm size and vacancy posting are exogenous – and thus cannot be used to study the welfare implications of mergers. We contribute to this literature along several dimensions by (i) considering the labor market and using nested-CES labor supply to flexibly capture worker substitutability across local labor markets, (ii) incorporating decreasing returns to scale (or isomorphically monopolistic competition in the product market), (iii) providing analysis of downward wage pressure, and (iv) 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 (2018) 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).[10] 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 increase 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 data on hospital mergers between 2000 and 2010 in the United States, they estimate that in the top quartile of concentration-increasing mergers, there are significant reductions in wages for skilled healthcare workers. Negative wage effects are larger in markets with higher initial concentration and lower unionization rates, suggesting that market power and labor market

[9]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).

[10]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.

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 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. The DOJ and FTC may challenge a merger if they determine that it may *"substantially lessen competition"* under Section 7 of the *Clayton Antitrust Act of 1914*. The law prohibits mergers that substantially lessen competition in *any* market, whether it is an input or output market, as the Horizontal Merger Guidelines recognize. However, until the Penguin Random House and Simon & Schuster merger case the agencies rarely paid attention to the impact of mergers on labor or other input markets, and never made them central to litigation. The focus of nearly all merger challenges has been the impact of mergers on consumers or intermediate buyers (e.g., United States (2022)).

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.[11]

To measure the effects of a merger on consumers, the DOJ and FTC must define a market. In the product market, a *Hypothetical Monopolist Test* is applied to define the boundary of a

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

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 usually taken to be 5 percent by the DOJ and FTC (DOJ and FTC, 2010, p. 10). In Section 4, we impose a market definition in our model, and under this definition, we estimate a low degree of substitutability of labor across markets. Since local labor markets are not close substitutes in our estimated model, a hypothetical monopsonist would engage in a small but significant and non-transitory decrease in wages, which is consistent with the Hypothetical Monopolist Test.

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.

After the affected market or markets are defined, the DOJ and FTC apply thresholds based on the Herfindahl-Hirschman Index (HHI) and merger-induced changes in the HHI, which may now be computed given the market definition.[12]

The 1984 and 2010 Horizontal Merger Guidelines lay out three categories of market concentration: unconcentrated, moderately concentrated, and highly concentrated markets. Our analysis focuses on highly concentrated markets. In the 2010 guidelines, markets with post-merger HHIs above 2500 are considered highly concentrated. In highly concentrated markets, mergers that increase the HHI by 200 points or more are presumed to be anticompetitive and "enhance market power" (DOJ and FTC, 2010, p. 19).

In the more stringent 1982 guidelines, markets with post-merger HHIs above 1800 were considered highly concentrated. In highly concentrated markets, the agencies presumed anticompetitive effects for mergers that increased the HHI by more than 100 points, and the agencies were *"likely"* to challenge such mergers (DOJ and FTC, 1982, p. 15).

Our results in Section 4.5 are designed to aid in formulating 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

[12]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.

used to evaluate various Herfindahl-based thresholds in the labor market.

The Horizontal Merger Guidelines also provide another route to merger review. Agencies may calculate the unilateral effects of mergers when markets cannot be adequately defined because products are highly differentiated. When sufficient data are available, agencies 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, or they 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.

A final point is that the HHI thresholds are based on the assumption that mergers typically produce efficiencies that offset the market power gains of the merging parties and are passed on to consumers in the form of lower prices. When mergers exceed the HHI thresholds, the agencies presume that prices will increase. Defendants may be allowed to rebut this presumption by showing that their merger will produce unusually strong efficiencies that will offset the negative price impact of enhancing market power or that the HHI increase overstates that enhancement of market power. In unilateral effects analysis, the efficiency analysis may be directly incorporated so as to make the price prediction. In litigation, efficiency arguments usually fail, but conventional wisdom is that agencies take efficiency arguments seriously when deciding whether to challenge a merger.

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 paid by readers. 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 in the labor market 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 that the market should include all books, regardless of the size of the advance. Based on that market definition, buyers would include numerous small publishers as well as giant self-publishing operators like Amazon, which would have greatly diminished the market shares of the big five commercial publishers. 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 merging 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 increase the HHI by 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, which were jury-rigged to measure downward pressure on author compensation. 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 from 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 analytically characterize 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. A representative household and a continuum of firms are 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,

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

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

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

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

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

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

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

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 and across markets, respectively. They jointly determine firm market power.[13] 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,

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

eroding 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, 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, 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 commuting zone and industry pairs, we will estimate a low θ, concluding that our market definition is consistent with a hypothetical monopsonist test.

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, $\mathbf{W}_j$. 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},

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

where the markdown is a function of the firm's payroll share of market j, s_{ij}, and is given by[14]

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

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

[14]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 $s_{ij} = \left(\frac{w_{ij}}{\mathbf{W}_j}\right)^{1+\eta} = \frac{\partial \mathbf{W}_j}{\partial w_{ij}} \frac{w_{ij}}{\mathbf{W}_j}$.

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:

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

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

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 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 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 (2018) 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 $(s_{1j}+s_{2j})$:[15]

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

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 analogously to the case of an arbitrary set of merging firms.[16]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 does not affect 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 decreases and employment index increases.*

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.*

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[15]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:

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

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

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

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

Proof. See Appendix A.

Subproposition 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 do not affect the labor market.[17] In both cases, firms 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 subpropositions 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 wages. A key step in the proof is showing that the post-merger combined share of the merging firms is larger than either firm's initial share. With its new market power, the merged firm contracts total employment across its plant to pay lower wages. As it cuts its wages, its competitors can 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 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 supported by evidence from mergers in US local labor markets.

Worker surplus neutrality. It is commonly believed that a merger is lawful if it causes no harm to the merging firms' trading partners in affected markets. The Horizontal Merger Guidelines,

[17] 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.

for example, indicate that regulators will not challenge mergers that do not increase prices or otherwise harm consumers of goods sold by the merged firms. Commentators have accordingly used a "consumer welfare" or consumer surplus standard, according to which a merger is lawful if consumer surplus is at least as large after the merger as before. In order to make contact with this literature (e.g. see Werden, 1996; Pittman, 2007; Farrell and Shapiro, 2010; Nocke and Whinston, 2022), we propose a simple definition of worker surplus neutrality. We base the definition on a household's problem in which profits are *not* rebated back to households in order to mirror the product market definition of consumer surplus neutrality.[18]

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* *Worker Surplus Neutral* *if* $\mathbf{W}_j = \mathbf{W}_j'$ *in all markets* $j \in [0,1]$.[19]

In other words, the merger does not change remuneration to workers. The market level labor supply curve implies that the household's disutility of labor supply is 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 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 neu-

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

[19]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.

trality, 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,

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

subject to the household's budget constraint,

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

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 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 $\{\widetilde{\alpha}, \widetilde{z}_{ijt}\}$:

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

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 $\widehat{\epsilon}^{Data}(s)$ for $s \in [0.05, 0.10]$	1.49	1.43
η	Within market substitutability	10.85	Average $\widehat{\epsilon}^{Data}(s)$ 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. $\widehat{\epsilon}^{Data}(s)$ 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 shock for firms with market shares between 5 percent and 10 percent. $\widehat{\epsilon}^{Data}(s)$ 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 shock for firms with market shares between 0 percent and 5 percent.

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:[20]

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

We define a market as 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.

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

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)

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 experiment 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 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 with a labor supply elasticity of 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, $\mathbb{E}[HHI_j]$.[21] 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. We estimate decreasing returns to scale of $\alpha = 0.94$, but in Appendix L, we consider increasing returns to scale ($\alpha = 1.03$). Increasing returns to scale gives rise to labor redundancy (pre-merger production can be achieved using fewer workers at one single plant). The exponent on labor, γ, is estimated to match the capital share (Barkai, 2020). The productivity shifter $\overline{Z}$ is chosen to match the mean firm size in the LBD exactly, and the labor disutility shifter $\overline{\varphi}$ is chosen to match mean worker earnings exactly.

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

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.[22]

Replication. We replicate the empirical setting of Arnold (2020) as closely as possible 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 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), and a slightly larger wage decline. Consistent with *Proposition 1*, firms' increased market power leads them to widen markdowns which reduces wages and employment. With employment and wages falling, the total payroll at the merging firms also declines. Consistent with the data, small wage declines generate large employment declines, 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.[23] Following Arnold (2020), we compute the change in worker earnings in high

[22]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.

[23]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

and medium concentration markets. Consistent with his results, we find that the 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 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 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 is a useful quantitative laboratory for examining potential merger guidelines. The empirical results from Arnold (2020) suggest that mergers in markets experiencing large changes in concentration and high initial concentration might warrant further review. In the following sections, we assess this claim and attempt to provide useful quantitative insights for policymakers and regulators tasked with evaluating the potential impact of mergers on labor market outcomes.

7 Penguin Random House Merger Simulation

To set the stage for our merger guideline section, we compute 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. In the language of our model, each firm is a single plant within this market. The market shares of the remaining firms in the publishing industry are taken from the judicial opinion (Pan, 2021, p. 27). There are three other large firms that, together with PRH and SS, make up the "Big Five" publishers and an unspecified number of small publishers outside of the "Big Five" whose market shares add up to eight percent. In our merger simulation, we assume that these small publishers comprise eight firms with one percent market share each. After constructing the market, we 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 as-

impact markets are all remaining markets.

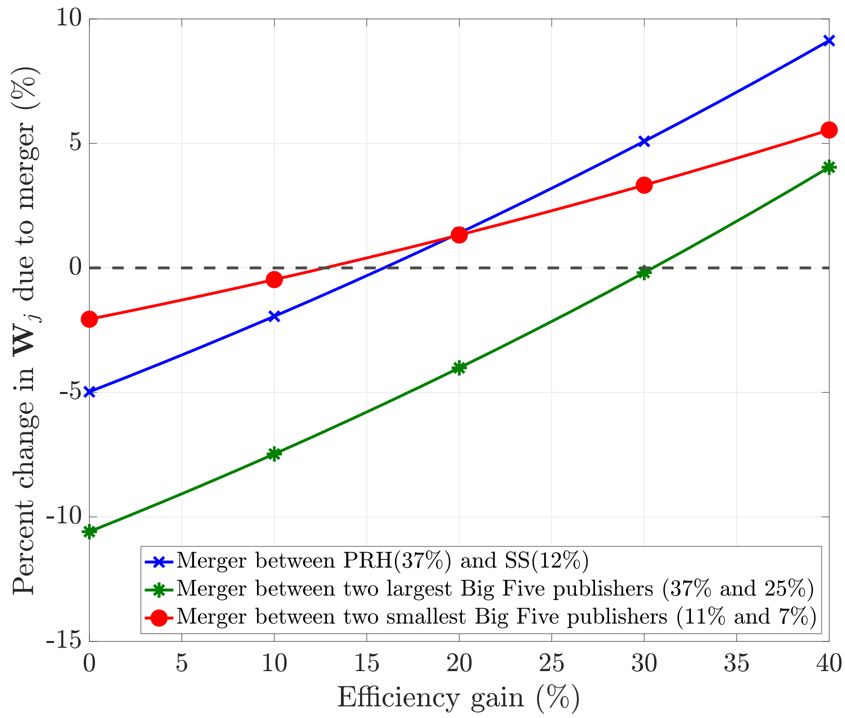

Figure 1: Expected change in wages in Penguin-Random-House & Simon-Schuster merger

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).

sumed in the *Penguin Random House* case (blue, crosses). Without any efficiency gain, the merger reduces market-level worker (author) wages by five percent. Under our estimated parameters in Table 1, the merger reduces the market-level wage index for any efficiency gain below 17 percent. Recall that worker surplus neutrality is only achieved when the change in the market 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 appendix G, we compare our estimates of the wage losses following the merger to the estimates reported in the judicial opinion (Pan, 2021, p. 57).

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 post-merger

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 assumed 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). We focus 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. Regulators can use our results 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 of mergers in product markets with a post-merger HHI greater than 1800 and a post-merger change in HHI (ΔHHI) greater than 200. In the 2010 guidelines, the HHI and ΔHHI thresholds for presumed anticompetitive effects were increased to 2500 and 200, respectively (see Section 3). In Appendix J, we consider alternate thresholds.

Our main exercise is applying the 1982 and 2010 product market merger thresholds to the labor market and computing 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).[24]

[24]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.

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.

The first column of Table 3 applies the more stringent screening thresholds from the 1982 merger guidelines. Panel I demonstrates that if we impose the most stringent threshold from DOJ and FTC (1982) and 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.

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 0.40 percent. Under an assumed efficiency gain of 1 percent, the blocked mergers lower the market-level wage index by 7.39 percent. Recall that to achieve worker surplus neutrality market-level wage index must remain above its pre-merger level. Thus, the permitted mergers yield worker surplus losses under an assumed efficiency gain of 1 percent. 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 0.04 percent and therefore yield worker surplus gains, while blocked mergers still lower the market-level wage index by 5.99 percent.

The second column of Table 3 applies the less stringent screening thresholds from the 2010 merger guidelines. When we block mergers that result in post-merger HHIs above 2500 and

DOJ/FTC market classification Threshold (HHI, ΔHHI)	——1982 guidelines—— *Highly Concentrated* (1800, 100) (1)	——2010 guidelines—— *Highly Concentrated* (2500, 200) (2)
I. Average REG		
Permitted mergers	4.68	5.96
Blocked mergers	19.97	22.88
II. Change in average $\mathbf{W}_j$ assuming 1 percent efficiency gain (%)		
Permitted mergers	-0.40	-0.63
Blocked mergers	-7.39	-10.37
III. Change in average $\mathbf{W}_j$ assuming 2 percent efficiency gain (%)		
Permitted mergers	-0.29	-0.51
Blocked mergers	-7.04	-9.93
IV. Change in average $\mathbf{W}_j$ assuming 3 percent efficiency gain (%)		
Permitted mergers	-0.18	-0.39
Blocked mergers	-6.70	-9.49
V. Change in average $\mathbf{W}_j$ assuming 4 percent efficiency gain (%)		
Permitted mergers	-0.07	-0.27
Blocked mergers	-6.35	-9.05
VI. Change in average $\mathbf{W}_j$ assuming 5 percent efficiency gain (%)		
Permitted mergers	0.04	-0.14
Blocked mergers	-5.99	-8.61

Table 3: Comparison of 1982 and 2010 guidelines.

Notes. Merger simulation designed to match representative set of merging firms based on Arnold (2020) (see text for details). Column (1) applies the 1982 guidelines. In Column (1), all mergers with post-merger concentration/change in concentration above ($HHI = 1800, \Delta HHI = 100$) are blocked. Column (2) applies 2010 guidelines. 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).

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 (1) and (2), 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. 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, and efficiency gains of mergers are 5 percent as assumed in the literature, then the 1982 guidelines of $(HHI = 1800, \Delta HHI = 100)$ achieve that goal, whereas the 2010 guidelines $(HHI = 2500, \Delta HHI = 200)$ do not. However, if the 5 percent assumption is too high, as some empirical research suggests (e.g., Blonigen and Pierce (2016) among others), then even the 1982 thresholds are perhaps too high. The methodology used to generate the results in Table 3 can be combined with regulators' priors on efficiency gains to form optimal thresholds.

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 panel A in Figure 2 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. A regulator can read off the required thresholds for a desired level of confidence.

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, less than 12.1 percent of mergers in which the smaller firm's payroll share exceeds 5 percent yield a worker surplus gain.

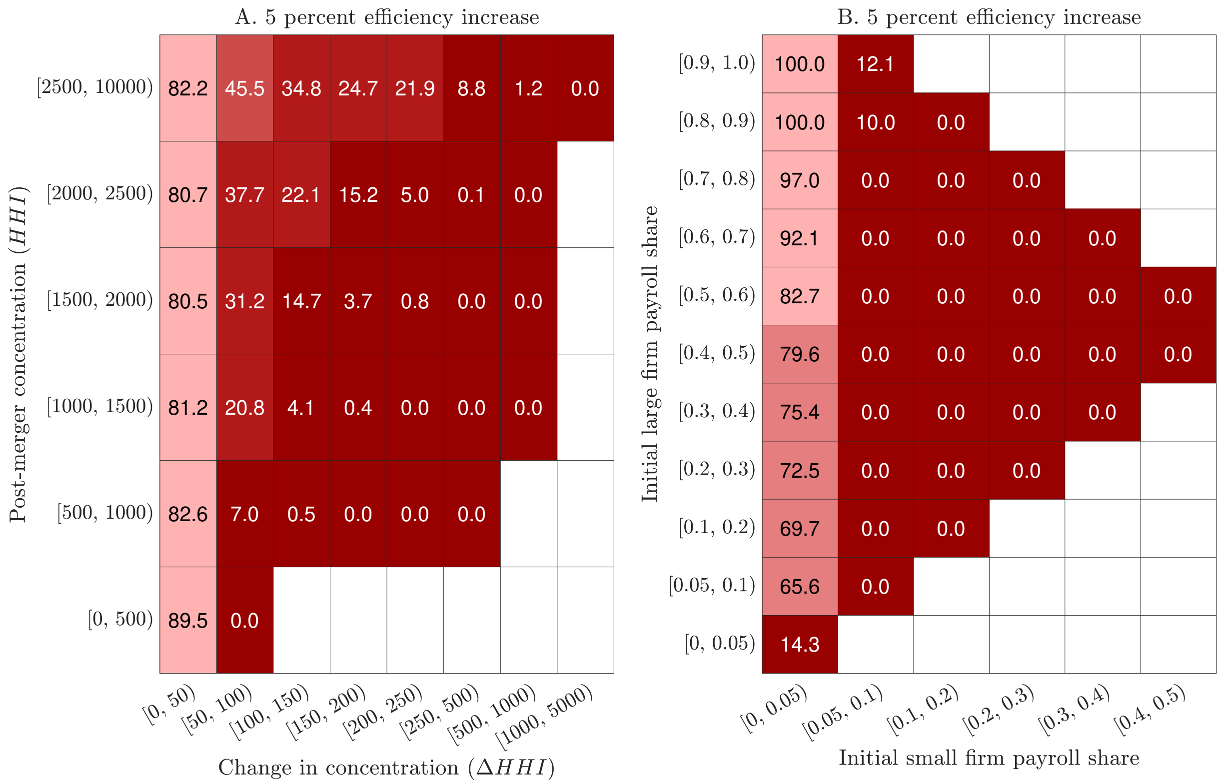

Figure 2: Fraction of mergers yielding worker surplus gain for 5 percent efficiency gain

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.

Note that the probabilities in panel B of Figure 2 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 non-merging 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 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 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 H, we provide an approximation to market-level worker welfare and 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. Our welfare approximations can be used to further condition merger review thresholds on the market size of the merger (Carlton (2010)). Lastly, in Appendix I, we provide type I and type II error rates for 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*.[25] 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

[25]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.

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) 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. 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.[26] 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

[26] 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.

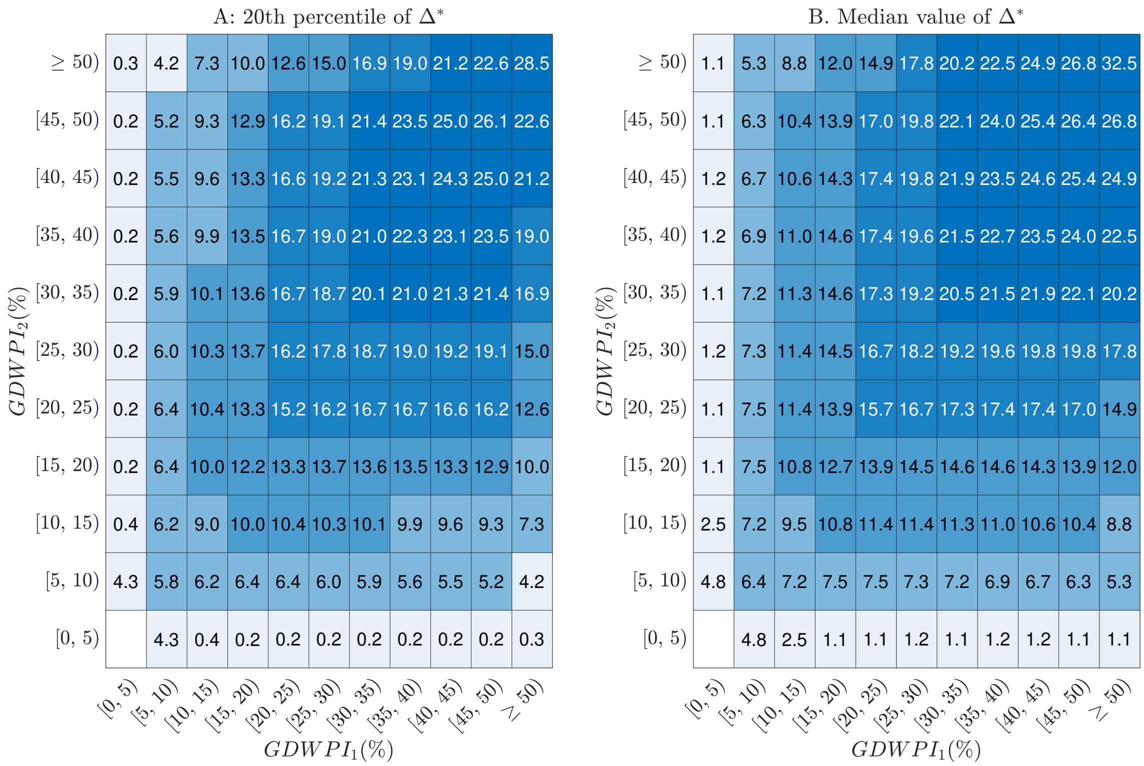

Figure 3: Productivity gains necessary to yield worker surplus neutrality stratified by gross downward wage pressure at each of the merging plants. The gross downward wage pressure is defined by equation (16), and multiplied by 100

can be readily applied to any industry with appropriate estimates of within- and across-market substitutability (η and θ). Our economy-wide estimates of η and θ are good benchmarks for initial merger reviews.[27]

Figure 3 plots the required efficiency gains (REGs) for worker surplus neutrality (Δ^*) as a 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).[28]
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

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

[28] 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.

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.

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 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, 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, 50 percent of mergers in which firms' GDWPI is between 5 and 10 percent yield worker surplus neutrality and 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, 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.

The tables in this paper and associated appendices can be combined with regulators' priors on efficiency gains 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.

Lastly, the framework for merger analysis developed in this paper can also be used in other areas of antitrust law where defendants are accused of imposing restraints on labor markets. Section 1 of the Sherman Act prohibits anticompetitive restraints of trade like wage-fixing and market division. In recent years, section 1 lawsuits have been brought against numerous firms that have entered no-poach and wage-fixing agreements, including major franchises like McDonald's, poultry processing firms like Perdue, and sports leagues like the NCAA. Cases have also been brought under section 2 of the Sherman Act against firms that engage in "monopolization" (or, here, monopsonization). For example, a Saudi-backed golf tour called LIV sued the PGA Tour for preventing its members from participating in LIV's tournaments (see Posner (2023) for a survey of the cases). In both section 1 and section 2 cases, plaintiffs must usually establish that defendants have market power within a clearly defined market, and prove that the restraint or conduct in question reduces worker compensation. The methods used in this paper can be further developed to improve analysis in both instances.

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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

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

$\square$

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.

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

Lemmas required for Proposition 3.1, Parts 3 through 6: 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)***

Proposition 3.1, Part 3: 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 $\boldsymbol{s}'_{jA} > \boldsymbol{s}_{jA}$. **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 increasing 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.

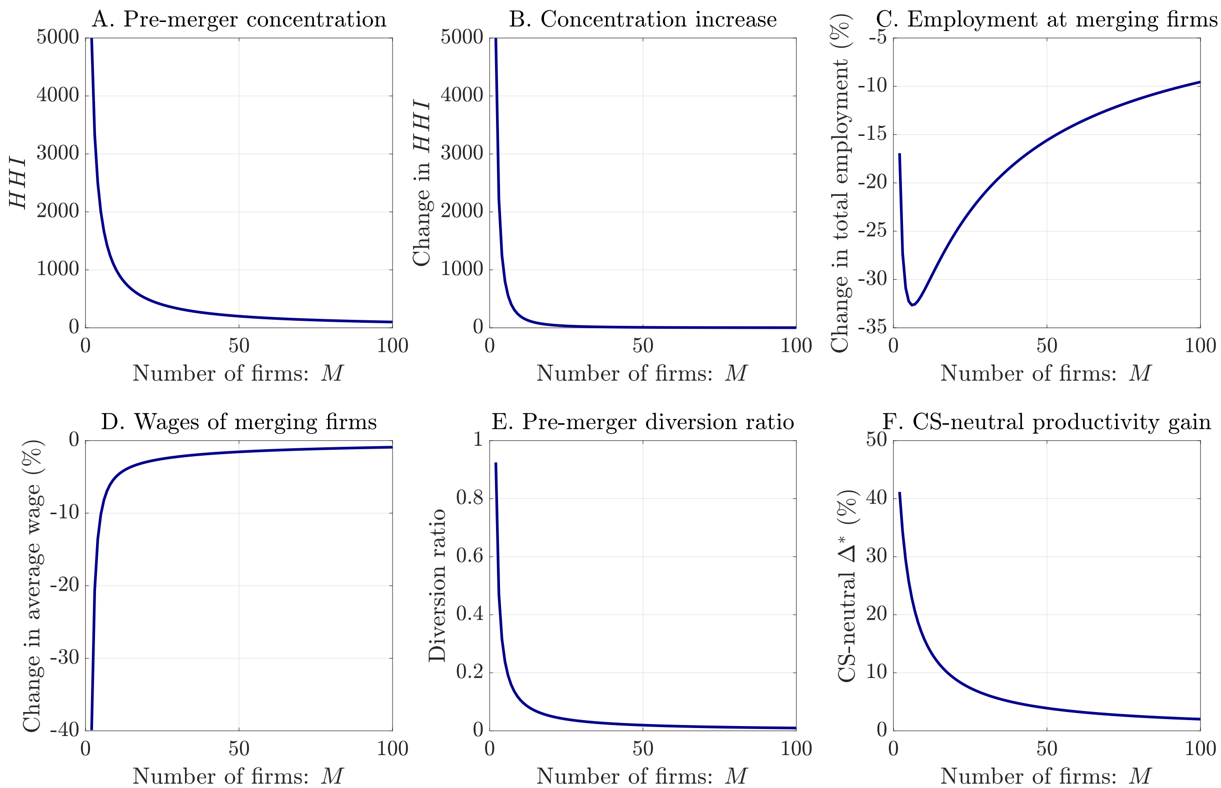

Figure 4: Effects of symmetric mergers by firms-per-market M_j.

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.[29] 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-

[29]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.[30] 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.

[30] 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).[31]
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, $\{\Delta_n^*\}_{n=1}^N$.[32] 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.

[31] 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.

[32] 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.

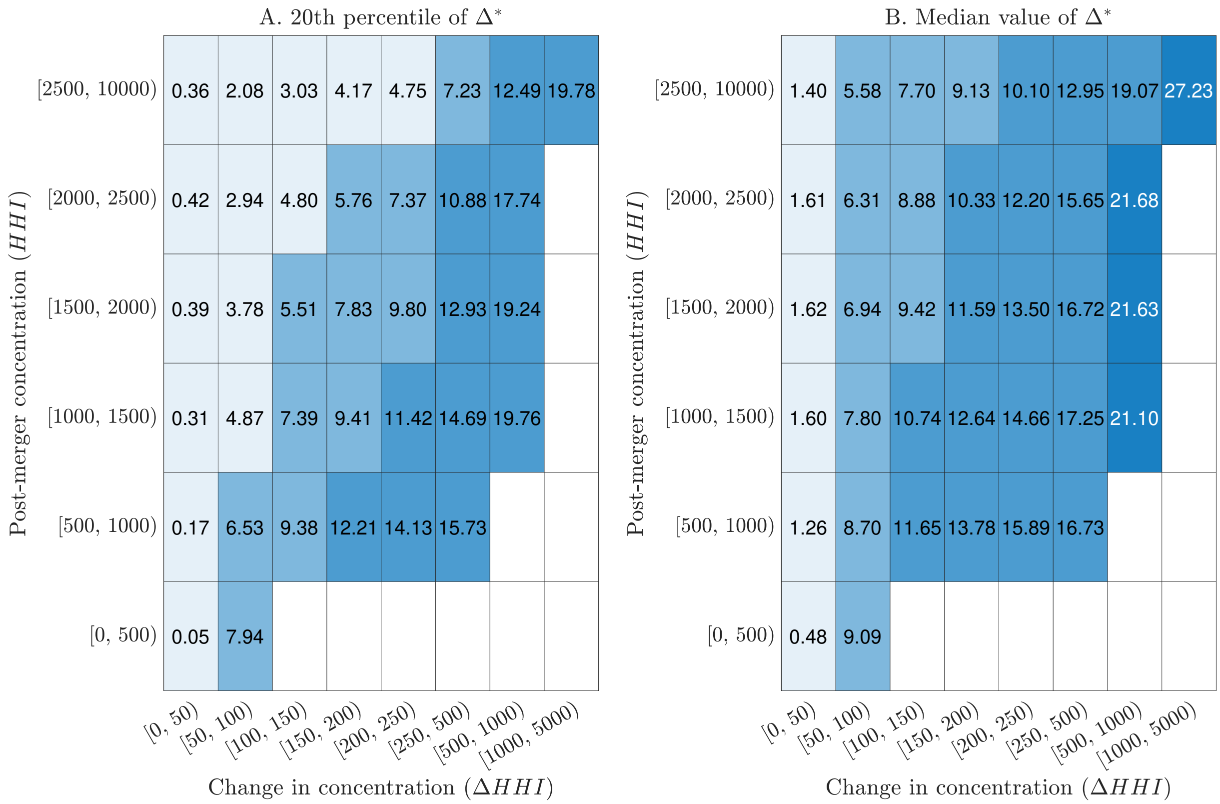

Figure 5: Percentiles of the distribution of worker surplus neutral efficiency gains $\{\Delta_n^*\}$

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

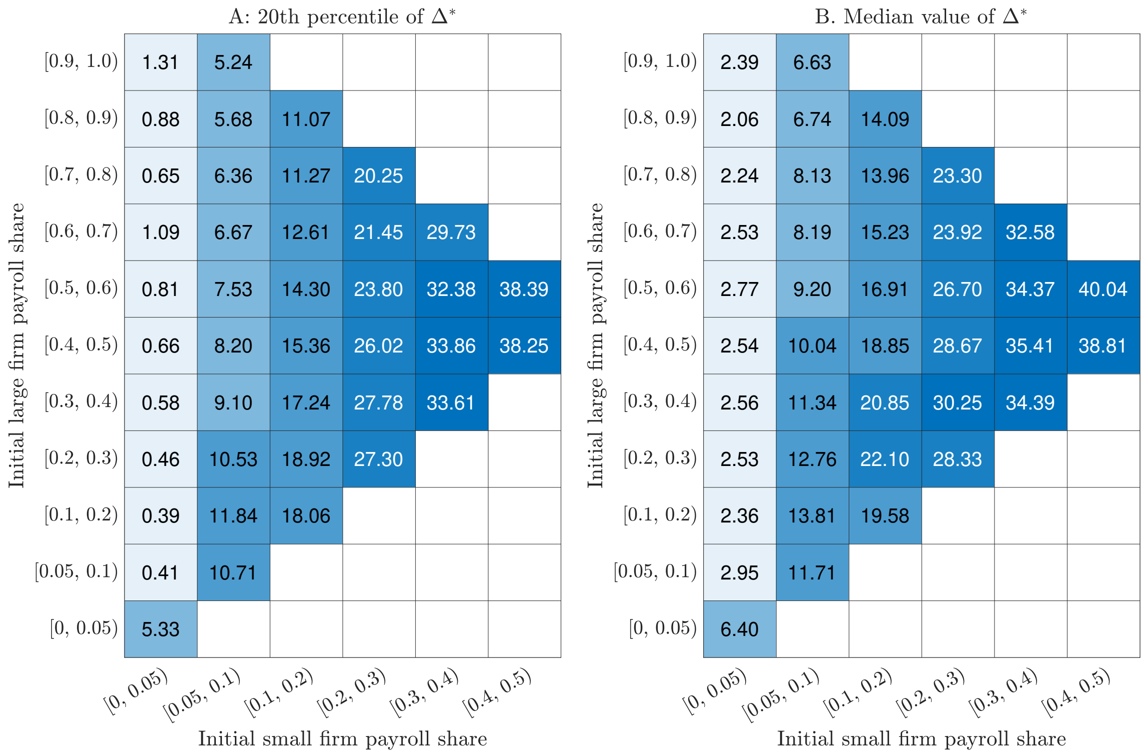

Figure 6: Percentiles of the distribution of required efficiency gains $\{\Delta_n^*\}$ for worker surplus neutrality - By shares

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.

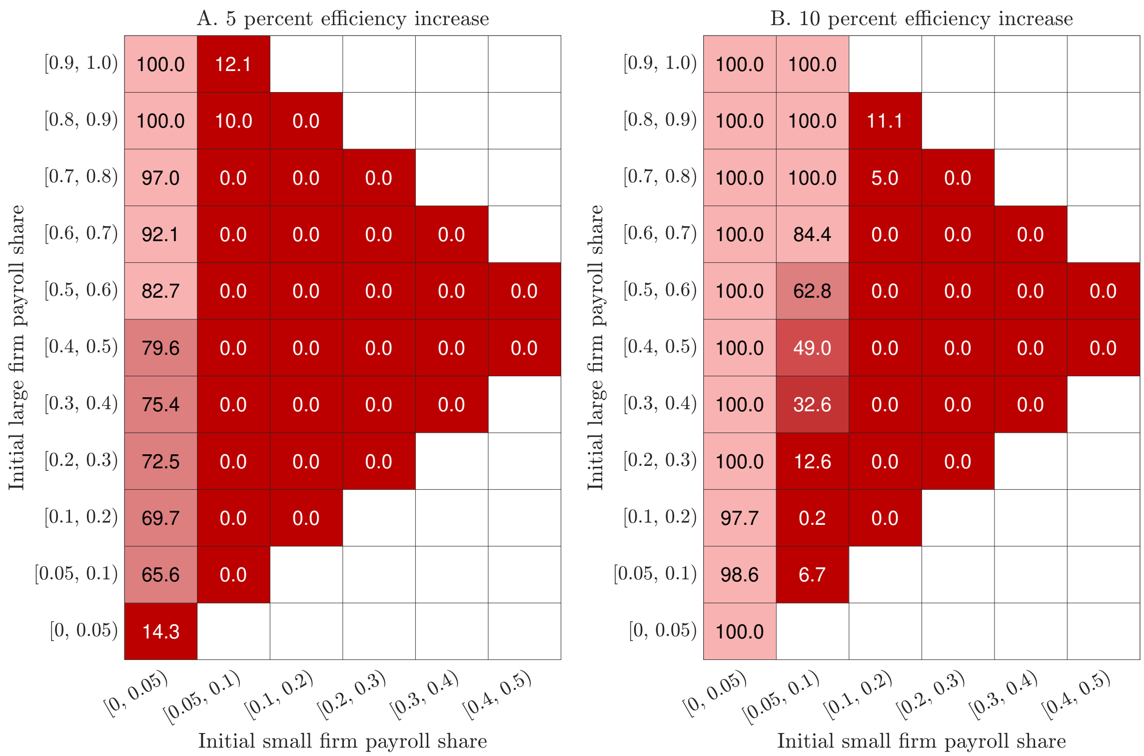

Figure 7: Fraction of mergers yielding worker surplus gains for efficiency gain $\Delta \in \{5\%, 10\%\}$ - By shares

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.

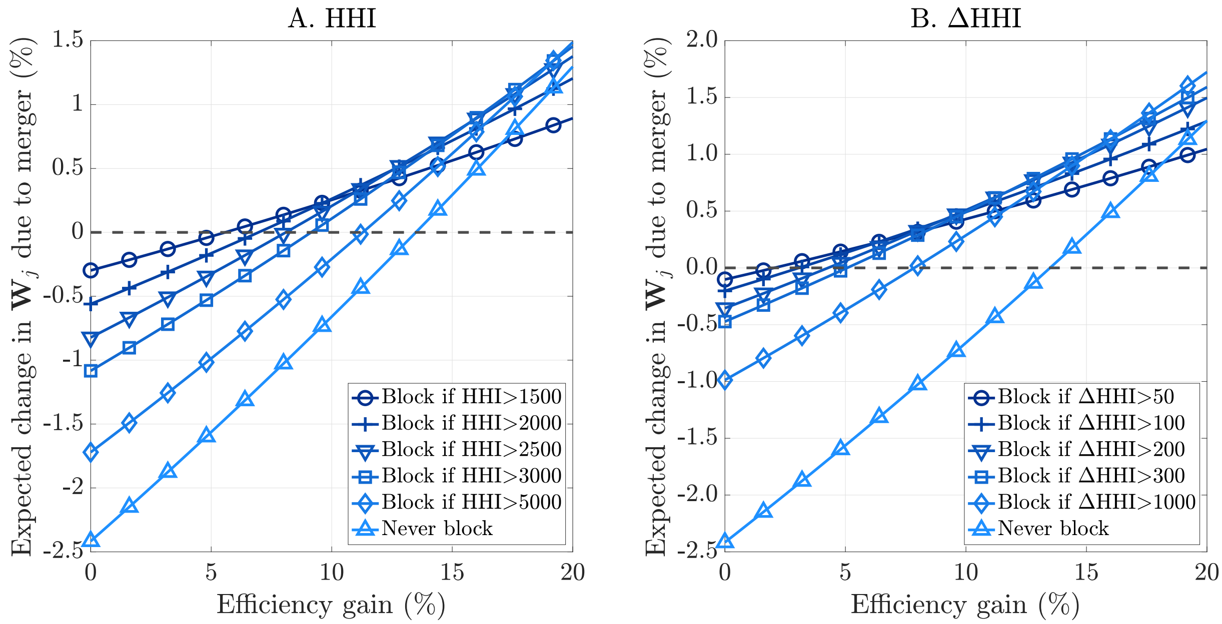

Figure 8: Expected change in market wage under alternative merger policies

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.

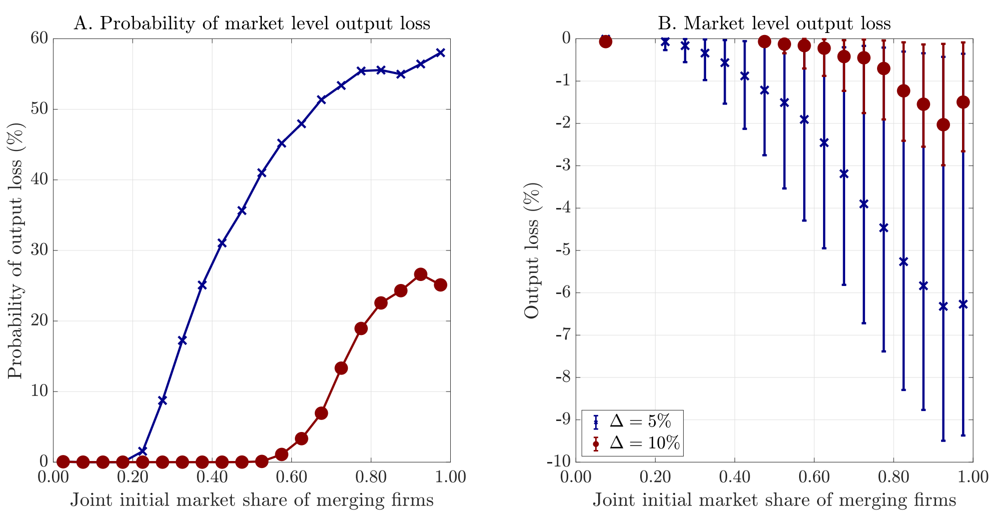

Figure 9: Output losses for a merger efficiency gain of $\Delta^+ \in \{5\%, 10\%\}$

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.

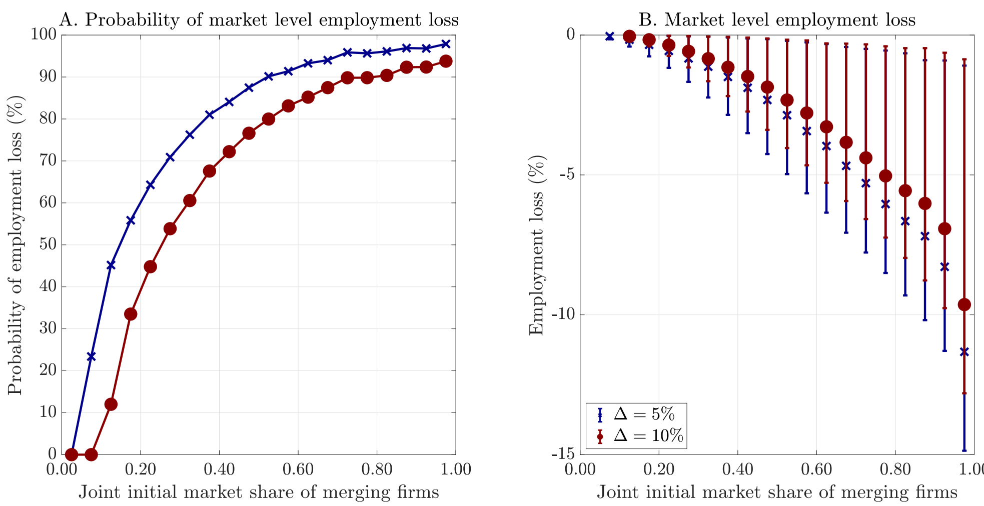

Figure 10: Employment losses for a merger efficiency gain of $\Delta^+ \in \{5\%, 10\%\}$

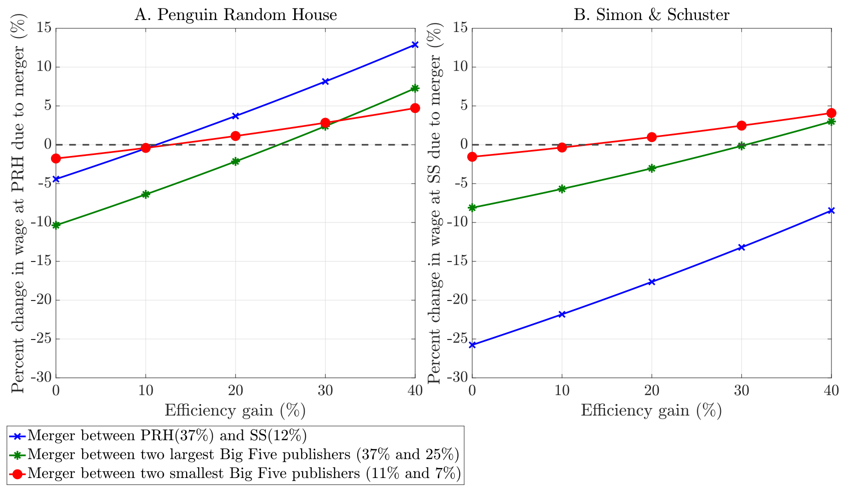

Figure 11: Expected change in wages in Penguin-Random-House & Simon-Schuster merger

Notes: Figures plots the merger-induced changes in wages at PRH and SS 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).

G Additional Results on the Penguin Random House Merger

Panel A in Figure 11 plots the change in the wage offered by Penguin Random House for various efficiency gains following a merger in the publishing market. Without any efficiency gain, the PRH and SS merger reduces PRH wages by approximately 4.5 percent. The efficiency gains required for workers at PRH to earn the same wage as before the merger is 10%. In comparison, the government witness in the judicial option (Pan, 2021, p. 57) estimated wage losses at PRH of $3.7-7.4$ percent.

Panel B in Figure 11 plots the change in the wage offered by Simon & Schuster. Without any efficiency gain, the PRH and SS merger reduces wages at SS by approximately 26 percent. The efficiency gains required for workers at SS to earn the same wage as before the merger is 55 percent. In comparison, the government witness in the judicial option (Pan, 2021, p. 57) estimated wage losses at SS of $6.4-19.2$ percent.

Why are our wage losses larger? The expert in the case adopted a second-price auction.[33] The optimal strategy is to bid one's true value. So competitors' bids do not respond to the PRH/SS merger, i.e. the 2nd/4th/5th etc. largest publishing houses have some exogenous values of winning the auction and they continue to bid those values. In our model, however, we have competitors cutting wages.

Since wages are strategic complements in our model, when the competitors cut wages, that

[33] See the expert's slides here: `https://www.justice.gov/d9/case-documents/attachments/2022/08/08/408636.pdf`

feeds back into merging firms cutting wages further. There is much evidence for such spillovers (Staiger, Spetz, and Phibbs (2010), Engbom and Moser (2017) among others), and so we believe our framework is a better approximation of what would have transpired had PRH and SS merged.

H 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:

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

The household budget constraint is given by

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

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 $\mathbf{N}$:

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

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

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

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

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

I 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. 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).

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).*

J Merger guidelines for moderately concentrated markets

The 1982 guidelines also state that the DOJ and FTC will sometimes, but not always, challenge mergers in markets with HHIs above 1000 and ΔHHIs above 100. The 2010 guidelines also state that mergers in moderately concentrated markets with HHIs between 1500 and 2500 and ΔHHIs above 100 may be challenged. Table 7 extends our analysis to moderately concentrated markets.

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.

In column (3), we apply the 2010 moderate concentration thresholds, and we 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.

K Model with market power in labor and product markets

The model in the main text assumes that product markets are perfectly competitive. In this section, we consider a version of the model that features market power in labor markets and product markets.

	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 7: 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).

Households. As in the model with perfectly competitive product markets, 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}, to maximize their flow utility, $U(\mathbf{C}, \mathbf{N})$, subject to their budget constraint. As before, the aggregate employment index, $\mathbf{N}$, is given by,

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

To allow for market power in product markets, we redefine the aggregate consumption index $\mathbf{C}$ as a CES aggregate over the continuum of markets and goods c_{ij} within each market:

$$\mathbf{C} := \left(\int_0^1 \left[c_{1j}^{\frac{\rho-1}{\rho}} + \cdots + c_{M_j j}^{\frac{\rho-1}{\rho}}\right] dj\right)^{\frac{\rho}{\rho-1}}.$$

The household's budget constraint is given by

$$\mathbf{PC} \;=\; \int_0^1 \left[p_{1j}c_{1j} + \ldots + \ldots p_{M_j j}c_{M_j j}\right] = \int_0^1 \left[w_{1j}n_{1j} + \cdots + w_{M_j j}n_{M_j j}\right] dj + \Pi,$$

where p_{ij} is the price of the good produced by firm i in labor market j and $\mathbf{P}$ is an aggregate price index given by

$$\mathbf{P} = \left(\int_0^1 \left[p_{1j}^{1-\rho} + \cdots + p_{M_j j}^{1-\rho}\right] dj\right)^{\frac{1}{1-\rho}}.$$

Product demand. The household optimality conditions for consumption c_{ij} yield the following inverse demand curve:

$$p_{ij}(c_{ij}) = c_{ij}^{-\frac{1}{\rho}} \mathbf{C}^{\frac{1}{\rho}} \mathbf{P}.$$

Note that in the model with competitive product markets, every firm charges the same price for their product. In the model with product market power, every firm faces a demand curve for their product, and prices will vary across firms.

Firms. We assume that firms are small with respect to the aggregate economy and take the indices $\mathbf{C}$ and $\mathbf{P}$ as given. As before, firms internalize their effects on the market-level indices $\mathbf{W}_j$ and $\mathbf{N}_j$.

The firm's profit maximization problem is given by:

$$\begin{aligned} \max_{p_{ij},c_{ij},n_{ij}} \quad & p_{ij}(c_{ij})c_{ij} - w_{ij}(n_{1j},\ldots,n_{M_j j})n_{ij} \\ \text{s.t.} \quad & p_{ij}(c_{ij}) = c_{ij}^{-\frac{1}{\rho}}\mathbf{C}^{\frac{1}{\rho}}\mathbf{P} \\ & c_{ij} = z_{ij}n_{ij} \\ & w_{ij}(n_{1j},\ldots,n_{M_j j}) = n_{ij}^{\frac{1}{\eta}}\mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}}\mathbf{N}^{\frac{1}{\theta}}\mathbf{W} \end{aligned}$$

Substituting the constraints in yields

$$\max_{n_{ij}} \quad z_{ij}^{1-\frac{1}{\rho}} n_{ij}^{1-\frac{1}{\rho}} \mathbf{C}^{\frac{1}{\rho}}\mathbf{P} - n_{ij}^{1+\frac{1}{\eta}}\mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}}\mathbf{N}^{\frac{1}{\theta}}\mathbf{W}.$$

The first-order condition is given by

$$\left(1-\frac{1}{\rho}\right) z_{ij}^{1-\frac{1}{\rho}} n_{ij}^{-\frac{1}{\rho}} \mathbf{C}^{\frac{1}{\rho}}\mathbf{P} - \frac{\partial w_{ij}}{\partial n_{ij}} n_{ij} - w_{ij} = 0.$$

Rearranging this expression and substituting the product demand curve in yields the following expression for wages:

$$w_{ij} = \frac{\mu(s_{ij})}{\nu} p_{ij} z_{ij},$$

where $\mu(s_{ij}) = \frac{\varepsilon(s_{ij})}{\varepsilon(s_{ij})+1}$ is the wage markdown and $\nu = \frac{\rho}{\rho-1}$ is the price markup. Note that markdowns vary across firms, but markups do not.

Mergers. Next, we consider a merger between firms i and i' in market j. As before, the merged firm chooses employment at both plants i and i' to maximize joint profits, internalizing any spillovers between the two newly merged plants. The profit maximization problem of the merged firm is given by:

$$\begin{aligned} &\max_{n_{ij},n_{i'j}} \quad \left[z_{ij}^{1-\frac{1}{\rho}} n_{ij}^{1-\frac{1}{\rho}} \mathbf{C}^{\frac{1}{\rho}}\mathbf{P} - n_{ij}^{1+\frac{1}{\eta}}\mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}}\mathbf{N}^{\frac{1}{\theta}}\mathbf{W}\right] + \left[z_{i'j}^{1-\frac{1}{\rho}} n_{i'j}^{1-\frac{1}{\rho}} \mathbf{C}^{\frac{1}{\rho}}\mathbf{P} - n_{i'j}^{1+\frac{1}{\eta}}\mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}}\mathbf{N}^{\frac{1}{\theta}}\mathbf{W}\right] \\ = &\max_{n_{ij},n_{i'j}} \quad \left(z_{ij}^{1-\frac{1}{\rho}} n_{ij}^{1-\frac{1}{\rho}} + z_{i'j}^{1-\frac{1}{\rho}} n_{i'j}^{1-\frac{1}{\rho}}\right)\mathbf{C}^{\frac{1}{\rho}}\mathbf{P} - \left(n_{ij}^{1+\frac{1}{\eta}} + n_{i'j}^{1+\frac{1}{\eta}}\right)\mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}}\mathbf{N}^{\frac{1}{\theta}}\mathbf{W}. \end{aligned}$$

The profit-maximization problem implies that post-merger wages are determined by a common markdown based on the combined market shares of the merged plants. For example, the wage at firm i is given by

$$w_{ij} = \frac{\mu_{ij}(s_{ij} + s_{i'j})}{\nu} p_{ij} z_{ij}.$$

This result follows directly from the first-order condition with respect to n_{ij} of the merged firm's profit maximization problem:

$$\begin{aligned}
&\left(1-\frac{1}{\rho}\right) z_{ij}^{1-\frac{1}{\rho}} n_{ij}^{-\frac{1}{\rho}} \mathbf{C}^{\frac{1}{\rho}} \mathbf{P} - \left(1+\frac{1}{\eta}\right) n_{ij}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} \mathbf{N}^{\frac{1}{\theta}} \mathbf{W} - \left(n_{ij}^{1+\frac{1}{\eta}} + n_{i'j}^{1+\frac{1}{\eta}}\right)\left(\frac{1}{\theta}-\frac{1}{\eta}\right) \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}-1} \mathbf{N}^{\frac{1}{\theta}} \mathbf{W} \frac{\partial \mathbf{N}_j}{\partial n_{ij}} = 0,\\
&\left(1-\frac{1}{\rho}\right) z_{ij} p_{ij} - \left(1+\frac{1}{\eta}\right) w_{ij} - \left(\frac{1}{\theta}-\frac{1}{\eta}\right) n_{ij}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} \mathbf{N}^{\frac{1}{\theta}} \mathbf{W} \frac{\partial \mathbf{N}_j}{\partial n_{ij}} \frac{n_{ij}}{\mathbf{N}_j} - \left(\frac{1}{\theta}-\frac{1}{\eta}\right) n_{i'j}^{\frac{1}{\eta}} \mathbf{N}_j^{\frac{1}{\theta}-\frac{1}{\eta}} \mathbf{N}^{\frac{1}{\theta}} \mathbf{W} \frac{\partial \mathbf{N}_j}{\partial n_{ij}} \frac{n_{i'j}}{\mathbf{N}_j} = 0,\\
&\left(1-\frac{1}{\rho}\right) z_{ij} p_{ij} - \left(1+\frac{1}{\eta}\right) w_{ij} - \left(\frac{1}{\theta}-\frac{1}{\eta}\right) w_{ij} s_{ij} - \left(\frac{1}{\theta}-\frac{1}{\eta}\right) w_{i'j} s_{ij} \frac{n_{i'j}}{n_{ij}} = 0,\\
&\left(1-\frac{1}{\rho}\right) z_{ij} p_{ij} - \left(1+\frac{1}{\eta}\right) w_{ij} - \left(\frac{1}{\theta}-\frac{1}{\eta}\right) w_{ij} s_{ij} - \left(\frac{1}{\theta}-\frac{1}{\eta}\right) w_{ij} s_{i'j} = 0,\\
&w_{ij} \underbrace{\left(1+\frac{1}{\eta}+\left(\frac{1}{\theta}-\frac{1}{\eta}\right)\left(s_{1j}+s_{2j}\right)\right)}_{\mu(s_{ij}+s_{i'j})^{-1}} = \underbrace{\left(1-\frac{1}{\rho}\right)}_{\nu^{-1}} p_{ij} z_{ij}.
\end{aligned}$$

L Model with increasing returns to scale

Next, we study the effects of mergers on worker welfare when firms operate, increasing returns to scale production technologies. Specifically, we change the value of the returns to scale parameter α from $\alpha = 0.94$ to $\alpha = 1.03$. We keep the rest of the parameters fixed at the values from table 1. Then, we compute required efficiency gains (REG) and perform the same welfare approximation as in appendix H. We summarize the results in table 8.

With increasing returns to scale, the required efficiency gains for worker welfare neutrality are lower than with decreasing returns to scale. For example, the average REG under the 1982 guidelines of ($HHI = 1800, \Delta HHI = 100$) is 1.8% with increasing returns to scale and 4.68% with decreasing returns to scale. Since the average required efficiency gain for worker surplus neutrality is lower with increasing than with decreasing returns to scale, average per-market worker welfare gains are larger. For example, under the 1982 guidelines and when we assume a 5% efficiency gain, permitted mergers generate an average worker welfare gain of \$19,963 per market with decreasing returns to scale and a gain of \$163,768 per market with increasing returns.

	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	1.32	1.80	1.52	2.85
Blocked mergers	17.47	17.97	17.67	20.27
II. Change in average welfare assuming 1 percent efficiency gain ($**)**				
Permitted mergers	-3,699	-25,427	-12,579	-77,651
Blocked mergers	-1,075,224	-1,127,336	-1,096,771	-1,336,538
III. Change in average welfare assuming 2 percent efficiency gain ($**)**				
Permitted mergers	42,641	20,686	33,637	-31,203
Blocked mergers	-1,017,708	-1,068,444	-1,038,662	-1,274,475
IV. Change in average welfare assuming 3 percent efficiency gain ($**)**				
Permitted mergers	89,778	67,588	80,647	16,022
Blocked mergers	-959,386	-1,008,730	-979,741	-1,211,549
V. Change in average welfare assuming 4 percent efficiency gain ($**)**				
Permitted mergers	137715	115,281	128,452	64,027
Blocked mergers	-900247	-948,183	-919,996	-1,147,747
VI. Change in average welfare assuming 5 percent efficiency gain ($**)**				
Permitted mergers	186,452	163,768	177,055	112,816
Blocked mergers	-840,279	-886,789	-859,415	-1,083,054

Table 8: 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).