Firm Heterogeneity and Trade-Induced Layoffs: An Empirical Investigation

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January 8, 2015

Abstract

We use a novel data set with verified observations of trade-induced layoffs by U.S. firms to study the interaction between firm productivity and trade liberalization as key determinants of firm-level job destruction due to trade. We find that patterns of trade-induced layoffs are broadly consistent with the predictions for firm-level employment generated by the Melitz (2003) heterogeneous firms theory –the number of trade-induced layoffs increases with firm productivity for non-exporting firms but decreases with firm productivity for exporting firms. The fact that exporting firms incur trade-induced layoffs at all invites a refined interpretation of the theory. Our findings suggest that exporting firms may lay off some workers who work in production for their shrinking domestic segments, while also engaging in some within-firm reallocation of workers. We also find that, even after controlling for productivity and export status, larger firms lay off more workers due to trade competition.

JEL Classification Codes: F10, F12, F14, F16, and J63
Keywords: Heterogeneous Firms, Trade Liberalization, Trade-induced Unemployment

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1 Introduction

Following Melitz (2003), a fast-growing literature has been studying the consequences of heterogeneity between firms on the effects of trade and trade liberalization. Many of these studies have clear structural predictions about the relationship between trade liberalization and firm-level layoffs when firms differ in their total factor productivity.[1] Despite the interest in the role of firm heterogeneity in shaping the relationship between trade liberalization and labor market outcomes, there is only a small number of empirical papers studying these links.[2] In this paper, we contribute to the literature by providing empirical evidence for the interaction between firm productivity and trade liberalization in the determination of firm-level job destruction in the U.S.

Most notably, we take advantage of a unique data set, the U.S. Department of Labor's Petition for Trade Adjustment Assistance (PTAA) database,[3] in order to overcome a standard difficulty in identifying these relationships – the question of whether observed changes in employment at the firm-level can be specifically attributed to trade competition as opposed to other influences. This data set provides us with a per-firm measure of what we call *trade-induced layoffs*: workers who suffer involuntary separations, or "layoffs", from their jobs in a given year due to trade competition and then go on to successfully petition the government for Trade Adjustment Assistance (TAA) benefits. The Department of Labor reviews each petition individually to determine if the worker separations were due to trade; therefore their decision whether or not to certify a given petition provides important information about whether or not these separations are "trade-induced" or not. Accordingly, this data grants us a unique opportunity to directly test basic theoretical predictions regarding firm-level employment responses to trade.[4]

Specifically, we test a basic set of predictions which we derive from the canonical Melitz (2003) "heterogeneous firms" model.[5] This essential theory, which is at the

[1]See Bernard et al. (2007), Egger and Kreickemeier (2009), Kambourov (2009), Helpman and Itskhoki (2010), Helpman et al. (2010), Davis and Harrigan (2011), and Felbermayr et al. (2011a) among others.

[2] See Trefler (2004), Menezes-Filho and Muendler (2011),Cosar et al. (2013) and Helpman et al. (2014) for prominent examples. A recent paper by Felbermayr et al. (2011b) also makes note of the lack of empirical work in this specific area.

[3]This database is constructed and maintained by the Employment and Training Administration at the Department of Labor.

[4]An important limitation of this data set is that it primarily captures separations from employment to unemployment, which as Hall (2005) notes are a relatively small share of the overall separation rate in U.S. manufacturing. We feel the valuable information it includes regarding whether or not separations are trade-induced outweighs this limitation.

[5]It would be incorrect to suggest that the Melitz (2003) model is not well-founded empirically; see Melitz and Redding (2014) for a survey of the many firm-level findings that have contributed to the model's microfoundations. Our proposed test draws more on the idiosyncratic properties of the model, along the lines of the potentially testable hypotheses proposed by Baldwin (2005).

heart of a substantial literature on firm-level responses to trade,[6] suggests that trade causes the least productive firms to stop producing and the most productive firms to start exporting, as only the most productive firms can bear the fixed costs associated with trade. As a result, market shares are reallocated towards the most productive firms. As we document in our review of the theory, the labor market implications are as follows: (a) net layoffs for the firms that do not export; and (b) net hires for the exporting firms. Furthermore, (c) both of these effects (net layoffs for non-exporters and net hires for exporters) should be stronger for more productive firms and also for more intense trade liberalization. We think that testing these inferences from the original Melitz model (especially with data that directly identifies trade-induced layoffs) is a notable contribution. Much of the recent quantitative literature on trade and firm-level employment has relied on these relationships to simulate labor market outcomes from trade liberalization,[7] but relatively few empirical studies have examined them directly.

Bringing Melitz's theory to our data requires careful consideration of two points in particular. First, our data only gives us information on layoffs (separations) in response to trade as opposed to the net changes in employment (including hires) predicted by the theory. Second, however, the trade-induced layoffs we observe in the data do not only occur at non-exporting firms, but at exporting firms as well. Because Melitz's theory does not provide an immediate reason why exporters should lay off workers due to trade, we deal with these two issues via a combination of approaches. As a first pass, we suppose that layoffs at all firms – exporters and non-exporters alike – reflect the decrease in the amount of labor used in domestic production predicted by the model. Later in the paper, we consider an alternate specification which maintains the assumption that the number of trade-induced layoffs increases with firm productivity for non-exporting firms, but also allows trade-induced layoffs to decrease with firm productivity for exporting firms.

Our initial reduced form estimation – based on the assumption noted above that exporting firms lay off domestic production workers – confirms that firm productivity, trade liberalization, and the interaction between the two are indeed key determinants of the magnitude of firm-level layoffs across all firms. Furthermore, the signs and relative magnitudes of the estimates we obtain are mostly consistent with the predictions we derive from the theory: trade liberalization appears to result in a decrease in the implied export productivity cutoff and in a (smaller in magnitude) increase in the implied productivity cutoff for domestic production, just as the theory would predict.

Under our second approach, we test how the relationship between productivity and layoffs differs for exporting and non-exporting firms. Theory does not offer a clear

[6] See Melitz and Redding (2014) for an overview of this literature.
[7] See for instance, Cosar et al. (2013) and Helpman et al. (2014), both discussed below.

prediction regarding this distinction. On the one hand, the model's implications for non-exporting firms are clear: the most productive non-exporters will need to lay off the most workers. On the other hand, the model does not dictate any particular relationship between layoffs and productivity for exporters, only that more productive firms will have more "net hires". Overall though, the relationship between total factor productivity (TFP) and layoffs for the firms in our data turns out to be negative and not statistically significant. Intuitively enough, once we decompose the effects of productivity by firm type, we find that this relationship is positive for non-exporters, but negative for exporters. This finding supports the natural interpretation that the tendency to increase employment (via "net hires") identified by the theory also translates directly into a tendency to retain more existing workers (via fewer layoffs) in a real-world setting. It also seems to suggest that exporting firms re-allocate at least some labor from domestic production to export production in response to trade liberalization.

We also note three other empirical findings of interest that help inform the interpretation of the model in light of the data. For example, first, we find that firm size (in terms of employment), has its own independent effect on the number of trade-induced layoffs even when controlling for firm productivity. While we do not find that not controlling for firm size leads to significant biases in the structural parameters, we do capture the fact that larger firms lay off more workers, which is in accordance with our priors. Second, we also find that higher labor costs are associated with lower probability to suffer from trade-induced layoffs. A possible explanation is that better paid workers might have more human capital and represent firms in industries in which the US has comparative advantage. Finally, we find that petitions that were initiated by a union are more likely to be certified. In addition, all else equal, the associated with these union petitions lay off more workers. Unions may affect the probability for TAA certification because they may be better organized when it comes to preparing applications for TAA eligibility/certification; it also may be that unions can use political means to affect certification outcomes. The positive effect of union representation on the number of trade-induced layoffs reflects the fact that workers affiliated with unions are probably more vulnerable to trade-induced layoffs.

Only a small number of papers have examined empirically the joint relationship that exists between trade liberalization, firm productivity, and firm-level employment outcomes. Of these, Menezes-Filho and Muendler (2011) is perhaps the most closely-related in that it examines, among other things, how separations at Brazilian firms in response to trade liberalization during the 1990s may have been different for exporters vs. non-exporters.[8] In comparison with their study, our findings are complementary

[8]They do include a direct control for firm productivity in one of their experiments for explaining separations (Table 6 in their paper). They show it is significant.

in two main ways. First, we find that productivity differences within exporters (as well as within non-exporters) have significant explanatory power over the number of separations. Second, the tariff liberalization that we consider for the U.S. can reasonably be thought of as relatively symmetric in nature compared with the largely unilateral import liberalization that took place in Brazil. Accordingly, our results may be more representative for a developed economy.

Trefler (2004) is also related in that he considers how trade liberalization affects separations for U.S. firms, and also examines how it affects firm productivity growth. However, he does not consider how the effects of trade liberalization on separations may differ based on firm productivity. We also emphasize that our specific focus on *trade-induced* separations grants us a unique perspective in this empirical context, which may yield better quality results.

Another related branch of the recent literature uses "structural estimation" of the heterogeneous firms framework, augmented to include labor market frictions, in order to quantify the effect of trade liberalization on labor market outcomes. We note Cosar et al. (2013) and Helpman et al. (2014) as representative works in this area. These studies use calibrated models to simulate the effects of a trade shock on firm-level separations. The fundamental difference between their approaches and ours (in addition to their use of structural estimation) is that we have actual data on separations due to trade shocks, which we use to test a (stripped-down version of) the relationships underlying their simulation dynamics.

These same dynamics are of course also found in the larger theoretical literature which embeds labor market frictions within a trade-with-heterogeneous firms framework, from which these structural estimation studies are derived. This literature is also very recent, dating back to the contributions by Egger and Kreickemeier (2009), Helpman and Itskhoki (2010), Davis and Harrigan (2011), and Felbermayr et al. (2011a). By virtue of the fact that we focus solely on the original Melitz (2003) model, our analysis omits the additional frictions that have been examined in this literature. Nonetheless, because Melitz (2003) is the common root of these models, it is still possible to compare and contrast the predictions of these models with our empirical results.

The remainder of the paper is structured as follows. In section 2, we review the theoretical model and we discuss its properties and implications for labor markets. Section 3 sets the econometric specification and discusses our data. Section 4 presents our main findings. Section 5 offers robustness experiments. Finally, Section 6 concludes.

2 Theoretical Setting

Our theoretical exposition draws from Melitz (2003).[9] However, we concentrate on the labor market implications of the model and we analyze the effects of productivity and trade liberalization, as well as their interactions, on trade-induced, firm-level layoffs.[10]

Autarky. We start, as Melitz does, by illustrating a simple autarky equilibrium in a single country in order to clarify the notation and the basic mechanisms at work governing productivity and labor demand. The key feature of the Melitz framework is a continuum of firms, each producing a differentiated variety ω, which are heterogeneous in a productivity parameter $\varphi > 0$. Each firm must pay an entry cost f_e in order to learn its φ, which is drawn from a distribution $g(\varphi)$, with a cumulative distribution $G(\varphi)$. The production technology requires only labor and is subject to $l = f + q/\varphi$, with f a common fixed cost that all firms must pay in order to produce. Consumer preferences are assumed to be CES with elasticity of substitution parameter $\sigma > 0$. This scenario implies that there exists a minimum productivity draw, φ^a, needed for a firm to stay in the market. The productivity distribution of the firms that stay in the market will be $\mu(\varphi) = \frac{g(\varphi)}{1-G(\varphi^a)}$, where $1 - G(\varphi^a)$ is the ex-ante probability of successful entry. This defines the aggregate productivity level $\tilde{\varphi}$ as a function of the cut-off level φ^a,[11] and also allows us to express average revenues as a function of φ^a: $r(\tilde{\varphi}) = \left[\frac{\tilde{\varphi}(\varphi^a)}{\varphi^a}\right]^{\sigma-1} \sigma f$. In equilibrium, because we can express firm revenues in autarky solely in terms of the zero-profit productivity cutoff, we can also express the equilibrium number of workers employed by firm in the same terms:

$$l^a = f + (\sigma - 1) f \left(\frac{1}{\varphi^a}\right)^{\sigma-1} \varphi^{\sigma-1}. \tag{2.1}$$

According to (2.1), more productive firms will employ more workers. Intuitively, more productive firms enjoy larger market shares and, therefore, need more workers.

Costly Trade The world consists of $n + 1 \geq 2$ identical countries.[12] Domestic firms may export their products to any country after they pay an additional fixed export cost, $f_x > 0$. Regardless of their export status, all firms pay the same overhead production cost f. In addition, exporting firms face higher marginal costs for their exports due to ad-valorem tariffs, t, which are assumed to be symmetric across all

[9]Ultimately, because we consider a symmetric liberalization, we could also have started from a model in which wages are exogenously fixed and arrived at the same essential relationships we explore in our empirical analysis. Nonetheless, we base our exposition on Melitz (2003) because we feel it is the canonical theory paper in the wider literature we wish to contribute to.

[10]We refer readers to Melitz's paper for full details on deriving the equilibria described below.

[11]More specifically, $\tilde{\varphi}(\varphi^a) = \left[\frac{1}{1-G(\varphi^a)} \int_{\varphi^a}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi\right]^{\frac{1}{\sigma-1}}$. As shown in Melitz (2003), $\tilde{\varphi}$ is also the average productivity level for the firms that choose to produce and stay in the market.

[12]Thus, each country has $n \geq 1$ potential trading partners, and all countries share the same wages and same aggregate variables.

trading partners. Price separability translates into separability of exporting firms' revenues: $r(\varphi) = r_d(\varphi)$, if a firm is selling only domestically, and $r(\varphi) = r_d(\varphi) + nr_x(\varphi) = [1 + n(1+t)^{1-\sigma}]r_d(\varphi)$, if a firm is exporting. Thus, each exporting firm's labor demand, $l^{ct}(\varphi) = l_d^{ct}(\varphi) + nl_x^{ct}(\varphi)$, can also be decomposed into its domestic, $l_d^{ct} = f + r_d(\varphi)\frac{\sigma-1}{\sigma}$, and exporting, $l_x^{ct} = f_x + r_x(\varphi)\frac{\sigma-1}{\sigma}$, portions, where superscript *ct* denotes 'costly trade.' While this decomposition is useful for illustrating the difference between exporter and non-exporter employment decisions, it should not be taken necessarily to mean that exporters make these decisions separately for each market segment. As we will see, our evidence suggests otherwise.

With trade, there will be two zero-profit productivity cutoff conditions: one for domestic profits, which determines the lowest productivity draw, φ^{ct}, needed for a firm to stay in business; and one for export profits, which determines the lowest productivity draw, φ_x^{ct}, needed for a firm to export, with $\varphi_x^{ct} > \varphi^{ct}$. Analytically, φ_x^{ct} is given by

$$\frac{r_x\left(\varphi_x^{ct}\right)}{\sigma} = f_x. \tag{2.2}$$

Intuitively, a firm's profits from selling in a foreign market, $r_x(\varphi)/\sigma$, must be at least equal to the fixed cost of exporting to that market, f_x, in order for the firm to choose to export.

In addition, the least productive domestic firms are driven out of the market by the opening to trade and thus there is an increase in the average productivity level and in the zero-profit productivity cutoff for domestic production. The labor equation for the firms that only serve the domestic market is very similar to the one describing the autarky equilibrium:

$$l^{ct} = f + (\sigma - 1)f\left(\frac{1}{\varphi^{ct}}\right)^{\sigma-1}\varphi^{\sigma-1}. \tag{2.3}$$

The only difference between (2.1) and (2.3) is that the zero domestic profit productivity threshold is higher in the trade equilibrium ($\varphi^{ct} > \varphi^a$). The equilibrium number of workers employed by an exporting firm is:

$$l^{ct} = \underbrace{f + (\sigma - 1)f\left(\frac{1}{\varphi^{ct}}\right)^{\sigma-1}\varphi^{\sigma-1}}_{\textbf{domestic}} + \underbrace{nf_x + (\sigma - 1)f\left(\frac{1}{\varphi_x^{ct}}\right)^{\sigma-1} n(1+t)^{1-\sigma}\varphi^{\sigma-1}}_{\textbf{export}}, \tag{2.4}$$

where, by the model's inherent separability, total employment in exporting firms can be decomposed into workers who produce for the domestic market and for export markets, respectively. As noted earlier, separability in employment (domestic vs. export) for the exporting firms should not be interpreted literally; however, we find it useful for illustrating the difference between exporter and non-exporter employment decisions and for setting our econometric specifications.

Trade Liberalization. Qualitatively, the effects of trade liberalization on productivity cutoffs are identical to the effects of opening to trade. Figure 1 depicts the changes in the zero-profit productivity cutoffs in response to trade liberalization. The export productivity cutoff decreases from φ_x^{ct} to φ_x^{tl} because, due to lower export

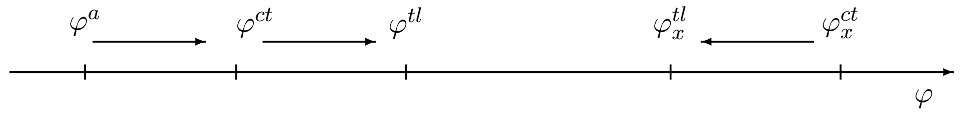

Figure 1: Firm Productivity and Trade Liberalization

costs,[13] firms with lower productivity levels now find it profitable to export. More exporters increase labor demand and bid up real wages. This results in market share losses, accompanied by layoffs, for some domestically producing firms, as well as an increase in the minimum threshold needed for domestic production (from φ^{ct} to φ^{tl}). Importantly, the increase in the zero-profit domestic productivity cutoff is smaller, in absolute value, than the decrease in the export productivity cutoff: $\left|\frac{\varphi^{ct}-\varphi^{tl}}{\varphi^{ct}}\right| < \frac{\varphi_x^{ct}-\varphi_x^{tl}}{\varphi_x^{ct}}$.

Following the steps of the derivation of firm-level employment outcomes when the economy moves from autarky to trade, we can express the number of workers laid off due to trade liberalization by the firms that sell only domestically as:

$$l^{ct} - l^{tl} = (\sigma-1)f\left[\left(\frac{1}{\varphi^{ct}}\right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}}\right)^{\sigma-1}\right]\varphi^{\sigma-1}. \tag{2.5}$$

Clearly, since $\varphi^{tl} > \varphi^{ct}$, the number of workers employed in a firm that only sells domestically will be lower after trade liberalization takes place. The change in employment, due to trade liberalization, for an exporting firm on the other hand is:

$$\begin{aligned} l^{ct} - l^{tl} &= (\sigma-1)f\left[\left(\frac{1}{\varphi^{ct}}\right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}}\right)^{\sigma-1}\right]\varphi^{\sigma-1} + \\ & n(\sigma-1)f_x\left[\left(\frac{1}{\varphi^{ct}}\right)^{\sigma-1}(1+t^{ct})^{1-\sigma} - \left(\frac{1}{\varphi^{tl}}\right)^{\sigma-1}(1+t^{tl})^{1-\sigma}\right]\varphi^{\sigma-1}, \end{aligned} \tag{2.6}$$

where, trade liberalization is measured by a discrete tariff reduction from t^{ct} to t^{tl}. Intuitively, trade liberalization has two opposing effects on employment for the exporting firms. First, the number of workers involved in production for the domestic

[13]The model assumes symmetric tariff liberalization, so that any decrease in domestic tariff protection is matched by an equivalent decrease in foreign protection, with symmetric effects on foreign firms. Alternatively, as noted in Baldwin (2005), we could have focused our exposition on symmetric reductions in fixed costs and obtained qualitatively similar predictions as the ones we explore in this paper.

market will be adversely affected by trade liberalization. This is captured by the first term, which is positive. Note that this term, and the corresponding effect, is identical to the total effect on employment for firms that sell only domestically. Second, the number of workers involved in production of exports will increase. This is captured by the negative second term in (2.6). That of course is not to say that exporting firms are laying off workers involved in domestic production only to hire additional workers for export production: in the empirical section of the paper we test whether exporting firms simply shift some workers from domestic production to export production in response to trade. The second effect unambiguously dominates the first for the firms that are exporters before and after the trade,[14] thus there will be net hires in the exporting firms. Furthermore, it is clear from (2.5) and (2.6) that the magnitude of employment changes (both layoffs and hires) is contingent on firm productivity as well. We formalize the effects of trade and production on employment in the following proposition.

Proposition 1 *Symmetric trade liberalization with the rest of the world will result in: (a) layoffs for firms that do not export, and (b) net hires for the exporting firms. Both of these effects will be stronger for the more productive firms and for more pronounced trade liberalization. Proof is in the Appendix.*

The intuition for these results is that once a country opens to symmetric trade liberalization with the rest of the world, firms that export gain net market share at the expense of firms that do not export. The increase in export profits for exporting firms is associated with more hires and a net increase in employment. Higher labor demand by the exporters bids up the wages paid to domestic labor, and forces some of the firms that only produce for the domestic market to exit, while others lose market share and lay off workers. Increased import competition from foreign exporters likewise drives down the reward to producing only for the domestic market.

These net changes in employment – both net hires for exporters and net layoffs for non-exporters – are larger for the most productive firms in each group because, for any given tariff, employment varies directly with a firm's productivity. Thus, more productive firms will always experience a larger absolute change in employment for a given change in tariffs. More productive exporters should hire more workers and more productive non-exporters should lay off more workers. Likewise, larger tariffs promote larger net changes in employment, for any given firm.

[14]Note that when the economy opens to trade from autarky, some less productive exporters suffer a profit loss due to the additional fixed export costs. For firms who have been exporting before and after trade liberalization, this is not an issue because the fixed cost of exporting do not change as a result of trade liberalization.

3 Linking Data with Theory

3.1 Data Description

This study covers the period 1980-2005 and we employ various series of US firm-level and sectoral data. The main advantage of our data is that it allows us to directly identify *trade-induced* job losses, in terms of actual firm layoffs that have been independently verified to be due to trade. Our source for data on trade-induced layoffs is the Petition for Trade Adjustment Assistance Database (PTAA). This rich database is constructed and maintained by the Employment and Training Administration of the U.S. Department of Labor. The PTAA data set includes records for all petitions for trade adjustment assistance that were filed in the United States during the period of investigation. According to the official TAA certification process guidelines, a TAA petition may be filed with the Department of Labor (DOL) by a group consisting of at least three workers, a company representative, a union, etc. In addition to a firm identifier, the PTAA data includes the 4-digit Standard Industrial Classification (SIC) code for the industry of the firm, the date when a TAA petition was filed, when and whether the petition was certified, and the estimated number of workers to be laid off by each firm (according to the petition) as an adverse consequence of foreign trade.

Another important feature of the TAA petition process is that filling out a TAA petition can reasonably be considered "practically free" for the laid-off group of workers: the process is straightforward, it involves only a single (short) form to be filled out, and there is no monetary cost. We expect then that workers who may have potentially been laid off due to trade has every reason to apply for benefits. By the same token, many workers laid off for other reasons besides trade should also find it worthwhile to apply for benefits. Importantly, the DOL does not grant certification automatically. They are expected to make their decision based on an investigation into whether or not foreign trade "importantly contributed" to worker separations. Indeed, many petitions for TAA benefits wind up being rejected. Data provided by the Congressional Research Service (Collins, 2012) shows that in 2003 (for example), only 53% of all TAA petitions were certified for eligibility by the DOL.[15] Accordingly, our measure of *trade-induced layoffs* is based solely on petitions that were certified for TAA benefits by the DOL.[16] Implicitly, we are relying on the DOL to make its decisions regarding the role of trade impartially and with reasonable accuracy. Nonetheless, there may be reason to be concerned that the DOL's certification decisions may be made based on unobservable characteristics (including subjective biases) that may be correlated

[15]Similar certification rates apply to our estimation sample.

[16]We also note that some petitions, roughly 6% of the original sample, were withdrawn by the petitioning groups before a ruling was made. We postulate that these withdrawals represent cases where the petitioning workers found new jobs shortly after applying.

with the number of layoffs; thus, we address potential selection bias in our econometric analysis.

We also note that there are some instances in the data, when laid off workers from the same firm file TAA petitions from different 4-digit sectors in the same year. Petitions coming from different sectors, even if associated with the same firm, undergo separate TAA certification processes. We treat those as separate observations in our data. Accordingly, in our estimations, we cluster the errors by firm and industry. This also allows us to keep the number of observations as large as possible. Aggregating the sample to the firm level produces very similar results.[17] There are also instances in the data when petitions from the same firm are filed in different years or during the same year but from different states. In each of those cases, individual petitions are given separate consideration in the TAA certification process and they enter our sample as separate observations.

To estimate total factor firm productivity, the main explanatory variable in our estimations, we follow the procedure from Petrin and Levinsohn (2003) and the Stata routine -*levpet*- by Petrin, Poi, and Levinsohn (2004). Petrin and Levinsohn (2003) emphasize the simultaneity problem and estimate production functions using intermediate inputs to control for unobservable productivity shocks. Following the existing literature, we transform our productivity variable in deviations from the mean. This is inconsequential for the significance of our estimates, but eases interpretation. Once we calculate total factor productivity for each firm, we merge these data with the certified firms from the TAA data set. This determines the size of the estimation sample for our main analysis to be 2145 observations, including all certified and denied petitions. The number of observations varies in the alternative specifications because in some of them we only use the 1259 observations for the certified petitions. In addition, the number of observations decreases due to unavailability of data for some of the instruments used in the IV specifications and also when we consider trade liberalization, which results in a loss of the observations for one year. It should also be noted that, even though our study covers an extended time span, we will be estimating cross-section econometric specifications, where each observation represents a petition-firm-year combination, and all variables are in real terms.

In addition to firm-level data on layoffs and productivity, we also employ various labor and trade variables at the firm and at the industry level. These include: firm-level total employment, union representation, labor costs, and export status; and, industry-level data on tariffs and imports. Total employment is measured by total number

[17] The multi-dimensionality of the PTAA data lends itself to merging with various firm-level and industry level data over a long period of time. Despite its richness and attractive features, however, we think that the PTAA data is underutilized. For further details and alternative uses of the PTAA database we refer the interested reader to Magee (2001), Yotov (2010), Yotov (2013), Kondo (2013) and Laincz et al. (2014).

of employees and taken from Compustat.[18] To construct the variable that captures union representation, we take advantage of an additional feature of the TAA database. Specifically, we use information from the data regarding whether or not the ID of the petitioning group matches the name of a known U.S. labor union. Overall, about 12% of all petitions in the data can be positively identified as having been originated by a union. Labor cost is calculated by multiplying the total number of employees with the average industry wage, which is taken from Bartelsman et al. (2001). We follow Denis et al. (2002) who use Compustat's firm-level data series on "Geographic Segment Type" to classify firms as either exporters or non-exporters.

We use tariff data to measure trade liberalization. Even though, non-tariff trade barriers (NTBs) are often a more significant and relevant measure of trade protection (see Felbermayr, 2011a), we choose tariffs for two reasons. First, comprehensive data on NTBs covering the period of investigation are not available. Second, we believe that US tariffs, which, for the period of interest in this paper, are determined under the regulations and rules of the General Agreement on Tariffs and Trade (GATT) and, later, by the World Trade Organization (WTO), are the more appropriate measure of protection for the current theoretical setting, which assumes symmetric trade liberalization. We use two sources of data on tariffs. Import-weighted average tariffs for the period 1980-1988 are from Bernard et al. (2006), and tariff data for the years after 1989 are from the Trade Analysis Information System (TRAINS).[19] In order to keep the sample size as large as possible, we use tariffs at the 3-digit SIC level. In addition, we employ current and 3-year lagged tariffs to measure trade liberalization and to obtain our main estimation results.[20] Data on sectoral imports are also from two sources. Data on imports up to 1989 are from Feenstra (1996), and imports for the years after 1989 are from the United Nations Conference on Trade and Development (UNCTAD) and TRAINS. Summary statistics for the main variables in our analysis are reported in the Appendix.

[18]The firm-level variables used in the calculation of TFP include (Compustat labels in parenthesis): Output (Net Sales), Material Cost (Total Cost of Goods Sold + Selling, General, and Administrative Expenses - Capital Depreciation and Amortization - Labor Cost), Labor (Total Number of Employees), Capital (Value of Property, Plant and Equipment Net of Depreciation), Investment (Capital Expenditures). In addition, we use Bartelsman et al. (2001) to obtain the following industry-level variables: Production Workers, Production Worker Wages, Deflator for value of shipments, Deflator for material costs and Deflator for Investment. For wages, ideally, one would like to use firm-level wages from our firm-level data; unfortunately, the number of missing values for this variable prevents this approach from being viable.

[19]We accessed TRAINS through the World Bank's World Integrated Trade Solution (WITS) software at http://wits.worldbank.org/witsweb/.

[20]Three years is often viewed in the literature as the average period needed for trade (an other) variables to adjust to trade shocks and policies. In the sensitivity analysis, we experiment with shorter and longer lags to find that the changes in our results are intuitive, and in accordance with the model's theoretical predictions. Results are also robust to measuring trade liberalization at a more aggregated level.

3.2 Econometric Specification

The Melitz model generates clear and sharp predictions about the effects of trade liberalization and productivity on firm-level employment. Unfortunately, some empirical limitations do not allow us to test the complete set of structural relationships in the model. In particular, even though our data set has the unique advantage of measuring *trade-induced* layoffs directly, it does not include information on hires by exporting firms due to improved access to foreign markets. Therefore, we will not be able to estimate (2.6) directly.

On the flipside, the theory likewise does not give us clear guidance for some of the patterns we observe in the data. In particular, the trade-induced layoffs we observe in the data (i.e. certified petitions for TAA benefits) not only occur at non-exporting firms, but at exporting firms as well. To deal with these two issues, we employ a combination of approaches. As a first pass, we take the (admittedly naive) assumption that layoffs at all firms – exporters and non-exporters alike – reflect the decrease in the amount of labor used to produce for the domestic market. Later in the paper, we also consider an alternate specification which will allow the relationship between productivity and layoffs to vary based on the export status of the firm.

Under the initial assumption that layoffs at all firms reflect the reduction in the number of workers used in domestic production, we can generate a general prediction for the number of layoffs by combining (2.5) with the first term in (2.6). The resulting expression is:

$$l^{ct} - l^{tl} = (\sigma - 1) f \left[\left(\frac{1}{\varphi^{ct}} \right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}} \right)^{\sigma-1} \right] \varphi^{\sigma-1}. \tag{3.1}$$

where, $l^{ct} - l^{tl}$ measures trade-induced layoffs, supposing initially that a change in the domestic zero profit productivity cutoff might induce layoffs for the domestic segment of exporters similarly to how it would induce layoffs for domestic producers. (As noted above, we relax this assumption in a subsequent specification.)

Estimating (3.1) directly will provide evidence for the relationship between productivity and trade-induced layoffs, but will say nothing about the relationship between trade liberalization and layoffs. To address this issue, we resort to the theoretical properties of the model. In particular, we employ the two zero-profit cutoff conditions to express the zero-profit domestic productivity cutoff φ^{τ}, $\tau \in \{ct, tl\}$, in terms of tariffs and the corresponding export productivity cutoff φ_x^{τ} as:

$$\varphi^{\tau} = \varphi_x^{\tau} \frac{1}{(1 + t^{\tau})} \left(\frac{f}{f_x} \right)^{\frac{1}{\sigma-1}}. \tag{3.2}$$

Plug (3.2) in (3.1) to obtain an expression for the number of layoffs caused by trade liberalization in terms of productivity and trade protection (ad-valorem tariffs):

$$l^{ct} - l^{tl} \;=\; (\sigma-1)f_x\left(\frac{1+t^{ct}}{\varphi_x^{ct}}\right)^{\sigma-1}\varphi^{\sigma-1} - (\sigma-1)f_x\left(\frac{1+t^{tl}}{\varphi_x^{tl}}\right)^{\sigma-1}\varphi^{\sigma-1} \quad (3.3)$$

(3.3) gives us an initial broad test for whether interactions between tariff reductions and productivity affect layoffs in a way that is consistent with the model. In particular, we expect to find a positive relationship between trade liberalization and layoffs as well as between productivity and layoffs. We also expect to find that liberalization results in a decrease in the zero-profit productivity cutoff for exporting, and that this decrease is smaller in magnitude than the corresponding increase in the cutoff for domestic production.

Our first attempt to test these predictions is to estimate a reduced-form linearized version of (3.3), noting that the righthand-side variables of interest implied by (3.3) are the following: (i) the interaction between firm productivity ($\varphi^{\sigma-1}$) and lagged tariffs ($(1+t^{ct})^{\sigma-1}$), and (ii) the interaction between firm productivity and current tariffs ($(1+t^{tl})^{\sigma-1}$). The implied lefthand-side variable is the number of trade-induced, firm-level layoffs ($l^{ct} - l^{tl}$). Lastly, we note that the distributions in levels of both trade-induced layoffs as well tariffs in our data are noticeably skewed. Therefore, we decided to use the logs of these variables for our reduced-form estimation of (3.3). The resulting econometric specification is the following:

$$LAYOFF_i = \tilde{\alpha}_0 + \tilde{\alpha}_1 L3.T_j * TFP_i + \tilde{\alpha}_2 T_j * TFP_i + \vartheta_j + \varepsilon_{ij}, \quad (3.4)$$

where: $LAYOFF_i$ is the logarithm of the number of trade-induced layoffs in firm i. TFP_i proxies for the term $\varphi^{\sigma-1}$, and measures total factor productivity of firm i. T_j and $L3.T_j$ are the logarithms of current and 3-year lagged ad-valorem tariffs in industry j, which proxy for $(1+t^{tl})^{\sigma-1}$ and $(1+t^{ct})^{\sigma-1}$, respectively.[21] Finally, ϑ_j denotes a set of 3-digit SIC industry fixed effects, which we use to control for unobserved sectoral characteristics that may affect trade-induced layoffs but are not explicitly included in the theoretical specification (such as comparative advantage, for example).[22]

According to the model's predictions, we would expect the coefficient, $\tilde{\alpha}_1$, in front of the first term, to be positive, implying a direct relationship between the interaction of total factor productivity and lagged tariffs and the number of workers laid-off by each firm due to trade liberalization. The estimate of $\tilde{\alpha}_2$ should be negative, implying

[21] Proxying for these interactions in this way obviously glosses over the role played by the elasticity of substitution (σ). We have experimented with estimating (3.3) structurally, subject to assuming a fixed value for σ. Results using this alternate approach are consistent with those shown in the paper for a reasonable range of assumed values for σ (e.g. 3 to 7.)

[22] We choose 3-digit SIC dummies to match the level of tariff aggregation that are used in the interaction variables. An additional advantage of this particular level of sectoral aggregation is that it delivers a representative number of firms from each industry.

an inverse relationship between the interaction of current tariffs and productivity. All else equal, higher current tariffs are associated with fewer layoffs. Finally, since theory suggests that the zero-profit export productivity cutoff falls (from φ_x^{ct} to φ_x^{tl}) due to trade liberalization, we expect $\tilde{\alpha}_1$ to be smaller, in absolute value, than $\tilde{\alpha}_2$. To see this, interpret the two coefficients (semi-)structurally, as $\tilde{\alpha}_1 = \frac{(\sigma-1)f_x}{(\varphi_x^{ct})^{\sigma-1}}$ and $\tilde{\alpha}_2 = -\frac{(\sigma-1)f_x}{(\varphi_x^{tl})^{\sigma-1}}$, respectively, and note that $\varphi_x^{ct} > \varphi_x^{tl}$ implies $\tilde{\alpha}_1 < |\tilde{\alpha}_2|$.

In the following section, we begin our empirical analysis by using (3.4) to test the predictions described above. We estimate at first using OLS, both with and without some additional controls – specifically, the size of the firm and whether or not the petition was submitted by a labor union. We then address the robustness of these results to biases due to both endogeneity and selection. Finally, we develop an alternative specification to explore how the relationship between trade-induced layoffs and productivity may differ across exporting and non-exporting firms.

4 Estimation Results and Analysis

4.1 Testing Baseline Predictions

We present our main estimation results in Table 1. The coefficient estimates for $L.T * TFP$ and $T * TFP$ are significant and have signs and relative magnitude as expected in equation (3.4). The interaction between lagged tariffs and productivity has a positive effect on layoffs, while the interaction of current tariffs and productivity has a negative effect on layoffs. In addition, we find that $\tilde{\alpha}_1$ is indeed smaller, in absolute value, as compared to $\tilde{\alpha}_2$.

According to Melitz's theory, more productive firms will always be larger, as they will have larger market shares, i.e. there should be perfect correlation between productivity and size. Often, this is not the case in reality, where the largest firms (in terms of employment) are not necessarily the most productive ones. The empirical implication is that, even after controlling for productivity, larger (in terms of employment) firms may lay off more workers. Additionally, we may also be concerned that workers who are represented by large unions may be more or less vulnerable to trade-induced layoffs and that union representation may be correlated with firm productivity.

To allow for these possibilities, in column 2 of Table 1, we estimate equation (3.4) again with the following added controls: (i) "SIZE", which proxies for the size of a firm using the logarithm of the total number of employees; (ii) "UNION", an indicator variable which takes a value of 1 if the petitioning workers identify themselves in the data as being represented by a known US labor union. The estimates of $\tilde{\alpha}_1$ and $\tilde{\alpha}_2$ remain significant and still have the expected signs and relative magnitude in the presence of these added controls. Neither firm size nor union membership affects our main conclusions regarding the empirical performance of the model.

With respect to firm size specifically, we provide empirical support for the hypothesis that larger firms lay off more workers. Specifically, we estimate that, all else equal, one percent increase in total, firm-level employment is associated with 0.13% increase in trade-induced layoffs, which is both statistically and economically significant. Overall, these results suggest that productivity and size may not be perfectly correlated as suggested by theory, and that in practice each of these variables may have separate effects on layoffs. With respect to unions, our findings suggest that union workers incur significantly more trade-induced layoffs (we obtain an in crease of about 0.65%) than other workers.

We have good reasons to believe that the OLS estimates presented so far may suffer from endogeneity bias. For example, as function of labor, TFP is endogenous by construction. Therefore, we need to account for this endogeneity due to simultaneity.[23] In addition, Yotov (2013) shows that trade-induced unemployment is an important determinant of US trade policy.[24] This implies that our trade variables, especially current tariffs, are endogenous as well. To address the issue of endogeneity, we estimate equation (3.4) using the instrumental variable and general method of moments (IV-GMM) estimator. For our instruments, we use lagged productivity, 5-year lagged tariffs, tariffs from the beginning of the period of investigation (1979), and the interactions between these terms.

Our expectation is that accounting for endogeneity bias will increase the magnitudes of our estimates for $\tilde{\alpha}_1$ and $\tilde{\alpha}_2$. We base this expectation on the two main arguments noted above. First, if layoffs are materially affecting the calculation of TFP, this consideration would cause us to overestimate TFP and thereby understate the relationship between TFP and layoffs.[25] Second, if US policymakers tend to raise tariffs in response to observed layoffs, as found by Yotov (2013), then controlling for reverse causality should result a stronger causal relationship between tariff reductions and trade-induced layoffs. By the construction of our econometric specification, both effects should work in the same direction.

IV-GMM estimates are reported in column 3 of Table 1.[26] Before we interpret the

[23] TFP might also be related to trade liberalization. For example, Bustos (2006) finds that increased export opportunities can have a positive influence on firm performance. She shows that a fall in trading partners' tariffs increases revenues for exporters, who in turn adopt new technologies profitable for more firms. Konings and Vandenbussche (2008) conduct an empirical study about the effects of anti-dumping protection on the productivity of domestic, import-competing firms and find that firms that receive protection improve their productivity. Pavcnik (2002) uses data on Chilean plants and finds evidence that productivity increases after trade liberalization for plants in the import competing sector. Trefler (2004) observes a similar finding for US firms.

[24] Furthermore, Yotov (2010) estimates that, when choosing the level of sectoral trade protection, the US government attaches four times more weight to the welfare of trade-affected workers.

[25] By siimilar reasoning, measurement error in the construction of TFP in general would tend to attenuate the observed relationship between TFP and layoffs.

[26] The sample size decreases by 23 observations due to unavailable data for some of the first-stage

results, we want to make sure that our instruments have the necessary properties to validate the IV estimator. We first test for under-identification, which checks whether the instruments are relevant and correlated with the endogenous regressors, and for overidentification, which tests whether our instruments are uncorrelated with the error term. χ^2 statistics from these tests are reported toward the bottom of Table 1. Based on these values, we reject the null (UnderId) hypothesis, which implies that the model is not under-identified, and we fail to reject the null (OverId) hypothesis, meaning that the excluded instruments are correctly excluded from the estimated equation.

Two properties of the IV-GMM estimates stand out. First, they confirm the presence of significant endogeneity bias in our OLS estimates. Both $\tilde{\alpha}_1$ and $\tilde{\alpha}_2$ are significantly larger in absolute value as compared to their OLS counterparts, as expected. Second, we find that our main predictions regarding the signs and relative magnitudes of $\tilde{\alpha}_1$ and $\tilde{\alpha}_2$ are robust to these concerns about endogeneity. The signs and significance of the added terms $SIZE$ and $UNION$ likewise are unaffected.

4.2 Accounting for Selection into TAA Certification

It is important to note that the analysis described thus far considers layoffs only for the firms that were certified by the DOL as having suffered from trade. Therefore, we are concerned that the results shown in columns 1 - 3 Table 1 may be biased due to selection into TAA certification.[27] To address this concern, we follow Heckman (1979) and set up the following econometric model:

$$LAYOFF_i = \alpha_0 + \alpha_1 L3.T_j * TFP_i + \alpha_2 T_j * TFP_i + \varepsilon_{1ij}, \tag{4.1}$$

where a layoff is observed if:

$$\gamma_0 + \gamma_1 EXCL_i + \gamma \mathbf{X_{ij}} + \varepsilon_{2ij} > 0. \tag{4.2}$$

Here, ε_{1ij} and ε_{2ij} are correlated and jointly normally distributed. Equation (4.2) is our selection equation, based on whether a firm suffers from trade or not. $EXCL_i$ is the exclusionary variable, which we describe below, and $\mathbf{X_{ij}}$ is a set of control variables, which, we believe, may affect the outcome of the TAA certification process. The control covariates that we use to estimate (4.2) include: UNION, an indicator for union-sponsored petitions, described above; the level of sectoral trade protection proxied by industry tariffs, TARIFF; the change in imports, Δ IMP, which is the key variable used by the government in the determination of TAA-certification outcomes

instruments.

[27]Specifically, we are concerned that, conditional on observable determinants of TAA certification, there may be unobservable characteristics that affect both the likelihood of selection as well as the associated number of layoffs.

and firm-level labor costs, LABOR_COST.

Finding a good exclusionary variable is crucial for sound econometric results in a selection model. Fortunately, a closer look into the Petition for Trade Adjustment Assistance data, which we use to measure firm-level trade-induced unemployment, gives us an excellent opportunity to construct a good exclusionary variable. In order to get TAA, laid-off employees have to go through a formal process of certification, where the government determines whether a firm is really affected by trade or suffers for any other reason, and verifies whether a group of workers are laid off due to trade related problems. Given the unified federal TAA certification procedures, one would expect that if two firms produce identical products and one of them is TAA-certified, the other should also be eligible to enter the program. Surprisingly, this is not the case. There are instances in the data when, even branches of the same company, producing identical products *but operating in different states*, have different outcomes when applying for TAA. This suggests that there might be some state characteristic that affects government's decision to grant TAA, which in turn we could use to identify our selection model.

Influenced by the large success of the political economy literature of trade and protectionism, we thought that overall political affiliation of a firm's state might be a good indicator of the firm's chances for TAA-certification. At the same time, whether a state is blue or red should not be related to any firm's performance, and trade-induced layoffs, in particular. Thus, we identify the political orientation of the state for each firm in our sample (based on the results in the election year preceding the petition year from our data) and use it as an exclusionary variable in the selection model (4.1)-(4.2). We assign a value of one to the exclusionary variable, POLIT, if a state is classified as republican.

To check whether our exclusionary variable has any explanatory power in the main estimating equation (4.2), we first re-estimate the specification from column (3) with POLIT as an additional covariate. As can be seen from column (4) of Table 1, we find no significant correlation between the political affiliation of a state and the number of workers laid off due to trade by a firm operating in this state. This is supported by the insignificant coefficient on POLIT. In addition, the signs, magnitude and significance of the other explanatory variables do not change. Overall, these results suggest that POLIT might be a good exclusionary variable for our selection model, as long as it is a significant predictor of the probability for TAA certification. We check this next.

Maximum Likelihood Estimation (MLE) results from the Heckman selection specification (4.1)-(4.2) are reported in column (5) of Table 1. We start with analysis of the selection equation. First, and most important, we see that the coefficient on POLIT in the first stage equation is significant. This, in combination with the significant estimate of the Mills ratio $\lambda = -0.589$ (standard error 0.352), reported toward the bottom of column (5), shows that the selection equation and the main equation are not independent. The negative sign of the coefficient on POLIT implies that, all else equal, it is less likely to become TAA-certified in a republican state.[28]

Turning to the estimates of the other covariates in our selection equation, we see that they are mostly in accordance with our priors. The negative sign of the coefficient estimate of TARIFF is expected: Higher level of tariffs are associated with lower probability to enter the TAA program. The intuition is that higher tariffs result in less imports and less lost market shares for the domestic firms, which, in turn, lay off fewer workers. An increase in imports increases the probability for TAA certification. This is captured by the positive and significant estimate of the coefficient on ΔIMP, and should not be surprising because, as mentioned earlier, import changes are key determinants of TAA- certification outcomes. Finally, we obtain expected signs for the estimates of the coefficients on $UNION$ and $LCOST$, however both estimates are not statistically significant.[29] The positive estimate on $UNION$ hints that the presence of unions may result in more certified petitions. The negative estimate on $LCOST$ suggests that higher labor costs are associated with lower probability of suffering from trade-induced layoffs and, therefore, qualify for TAA. A possible explanation is that better paid workers might have more human capital and represent firms in industries in which the US has comparative advantage.

Next, we turn to the main (second-stage) estimation results, which are obtained after controlling for selection (and for endogeneity as well). Qualitatively, the new findings are similar to the IV-GMM results presented in column (3), which only control for endogeneity, and to the OLS estimates from the first two columns of the table. The estimated coefficient on the interaction between TFP and lagged tariffs is positive and significant, while the estimate of the coefficient on the interaction between TFP and current tariffs is negative and significant. In addition, the estimate of α_1 is smaller, in absolute value, as compared to the estimate of α_2. Quantitatively the 'selection' estimates are also similar to their IV counterparts. However, the estimate of α_2 becomes smaller in magnitude. This suggests some upward bias (in terms of magnitude) when selection bias is not controlled for. A possible explanation for this result is that the political affiliation of a state is associated with the current level of sectoral trade protection.

[28]This, by itself, is an interesting finding that deserves more attention. However, for the current purposes, our only goal is to find a reasonable (theoretically sound and satisfying the econometric tests) exclusionary variable. POLIT meets our needs. More importantly, the estimate on POLIT is significant, which reinforces our hypothesis that it is indeed a good exclusionary variable. For detailed analysis of the determinants of the probability for TAA certification, we refer the curious reader to Laincz et al. (2014) who use the same dataset, develop a simple theoretical framework, and offer rigorous empirical analysis to study the effects of political support and political affiliation at the state level on the probability of TAA certification.

[29]We do find that both $UNION$ and $LCOST$ become significant in the selection equation later on when we consider an alternate specification.

4.3 Identifying a Role for Export Status

So far, our empirical findings are in perfect accordance with the basic predictions we derived from Melitz's model. Across all specifications, the coefficient estimates are always significant and have the expected signs. In addition, the relative magnitude of the estimates supports the prediction of a falling zero-profit export productivity cutoff, which we also translated into an increasing (but less so) zero-profit domestic productivity cutoff. While our results are encouraging in terms of their statistical significance and relative magnitude, we still need to address some important caveats.

In particular, if we take our initial simplifying assumption at face value – that layoffs by exporting firms directly reflect the shrinking size of their domestic production operations – then by Proposition 1, we should expect to find positive partial correlations both between trade liberalization and layoffs as well as between productivity and layoffs. Currently, our empirical results based on (3.3) suggest that the (positive) effect on layoffs of a reduction in tariffs is overall more pronounced at more productive firms. This inference is misleading in terms of telling us about the overall relationship between layoffs and firm productivity, however; the direct partial effect of productivity on layoffs implied by our estimates may not necessarily be positive.

To see this, we obtain a direct measure of the overall partial relationship between productivity and layoffs as follows. First, we use the estimates from column (5) (our most preferred specification that simultaneously controls for endogeneity and selection), along with the mean of lagged and current tariffs, to estimate the effect of productivity on layoffs as:

$$\frac{\partial LAYOFF_i}{\partial TFP_i} = \widehat{\alpha_1}\overline{L3.T} + \widehat{\alpha_2}\overline{T}, \tag{4.3}$$

where $\overline{L3.T}$ and $\overline{T}$ are the weighted average levels of the 3-year lagged $L3.T_j$'s and the current T_j's, respectively, across all sectors. To construct the tariff means, we use import values as weights. Interestingly, we estimate the effect of productivity on layoffs to be negative and lacking in significance, $\frac{\partial LAYOFF_i}{\partial TFP_i} = -.039$ (standard error .101), whereas we had hypothesized a positive relationship based on (3.3). It is important to keep in mind however that, in reality, (3.3) reflects the change in employment for domestic production only: there is nothing in the original theory which suggests that exporting firms will not shift workers from domestic production to export production when the economy opens to trade. A natural hypothesis to test then will be whether the relationship between layoffs and productivity depends on export status.

To dig deeper, we first introduce an alternative specification of our original equation for layoffs (3.3), which we express as:

$$l^{ct} - l^{tl} \;=\; (\sigma - 1) f_x \left[\left(\frac{1 + t^{ct}}{\varphi_x^{ct}} \right)^{\sigma-1} - \left(\frac{1 + t^{tl}}{\varphi_x^{tl}} \right)^{\sigma-1} \right] \varphi^{\sigma-1}. \qquad (4.4)$$

(4.4) translates into the following alternate econometric specification:

$$LAYOFF_i = \beta_0 + \beta_1 LIBER_j + \beta_2 TFP_i + \beta_3 SIZE_i + \beta_4 UNION_i + \vartheta_j + \epsilon_{ij}, \quad (4.5)$$

Here, $LAYOFF_i$ and TFP_i are defined as before. $SIZE_i$ is the logarithm of total, firm-level employment, and $UNION$ captures union representation. ϑ_j is the set of 3-digit SIC fixed effects. Finally, $LIBER_j$ proxies for trade liberalization, and is constructed as the difference between the logarithms of 3-year lagged and current ad-valorem tariffs in industry j. According to theory, we expect the estimate of β_1 to be positive, indicating that trade liberalization causes layoffs. The estimate of β_2 however may be positive or negative, reflecting the fact that, by Proposition 1, higher productivity affects overall employment differently for exporters vs. non-exporting firms.

Estimates of (4.5), obtained after simultaneously controlling for selection and endogeneity, are reported in column (6) of Table 1.[30] First we note two differences in the estimates from the selection equation. We now obtain significant estimates of the coefficients on both $UNION$ and $LCOST$, which also preserve their expected signs. Turning to the main estimates from the second stage, as before, we find that larger size, in terms of employment, and union representation result in more trade-induced layoffs. The estimates on $SIZE$ and $UNION$ are positive, significant and similar in magnitude to the previous results. Also, as predicted by theory, more trade liberalization is associated with more layoffs. This is captured by the positive and significant estimate of the coefficient on $LIBER$. Given our definition of this variable, the estimate on $LIBER$ implies that one percent increase in the ratio between 3-year lagged and current tariffs is associated with about 32 percent increase in firm-level layoffs. Finally, we estimate the coefficient on TFP to be negative but lacking significance, which contradicts our initial predictions.

Why do we obtain insignificant TFP effects? An intuitive hypothesis is that the relationship between productivity and trade-induced layoffs may depend on firm export status. In particular, we suspect that, in reality, more productive exporters lay off less workers. In order to allow for this possibility, we extend specification (4.5) to include a dummy variable, EXP_i, which takes a value of one for exporters, and an interaction term, $EXP_i * TFP_i$, which will allow us to decompose productivity effects

[30]Results obtained with alternative estimators (e.g., IV or OLS) are similar and are available upon request.

by firm type.[31] If exporting firms are simply shifting part of their labor force from producing for the domestic to producing for the foreign market, then we can interpret Proposition 1 to mean that more productive exporters will probably suffer less trade-induced layoffs. The new econometric specification becomes:

$$\begin{aligned} LAYOFF_i &= \gamma_0 + \gamma_1 LIBER_j + \gamma_2 TFP_i + \gamma_3 SIZE + \gamma_4 UNION_i \\ &\quad + \gamma_5 EXP_i + \gamma_5 EXP_i * TFP_i + \vartheta_j + \zeta_{ij}, \end{aligned} \tag{4.6}$$

Results from the estimation of (4.6) are reported in the last column of Table 1.[32] The findings are in accordance with our expectations and hypothesis. In particular, we see that the relationship between productivity and trade-induced layoffs is positive for the firms that only sell domestically. This is captured by the positive and significant coefficient estimate on TFP_i, and is as predicted by the theoretical model. In addition, we estimate a negative and significant relationship between productivity and layoffs for the exports. This supports the natural assumption that, rather than strictly laying off workers for domestic production and hiring new workers for exports, exporters also shift some labor internally. Finally, we see that the coefficient estimates on $SIZE$, $UNION$ and $LIBER$ are not affected by the introduction of the new control variables. This is encouraging evidence in support of the general predictions of the firm-heterogeneity theory.

5 Sensitivity Analysis

We finish with several experiments that demonstrate the robustness of our findings. We split the sensitivity analysis in two groups. First, we check whether our findings are robust to the inclusion of additional covariates and control variables that could potentially be correlated with trade-induced layoffs. Second, we employ alternative dependent variables. It is possible that during the long time span of our sample firms were affected by cyclical changes, some of the firms exited, and/or perhaps there were structural changes in the economy that affected changes in employment at the sectoral level or at the firm level. All of these factors may have influenced our measure of trade-induced layoffs. If so, our main estimates could be subject to omitted variable bias. We introduce several additional controls sequentially.

We start with the introduction of sectoral employment. Columns (1)-(3) of Table 2

[31] As noted in the data section, we follow Denis et al. (2002) who use the series "Geographic Segment Type" from Compustat in order to classify a firm as an exporter. In accordance with theory, our data reveals that many (in fact the majority) of the firms who layoff workers due to trade are indeed exporters.

[32] To estimate (4.6), we simultaneously control for endogeneity and selection. Breaking the sample by firm type and estimating two separate systems produces very similar results. We prefer the estimates obtained with the aggregate sample because those are more efficient.

replicate our most preferred specifications from columns (5)-(7) of Table 1, respectively, with sector-year employment as an additional covariate in our estimating equation. It should be noted that in the presence of sector fixed effects, this variable captures the change in employment from year to year. Two findings stand out. First, we find that the coefficient estimate for the additional control variable is positive and significant. Interestingly, this result suggests that sectors where employment increased by more were also the sectors that laid off more workers due to trade. This result, therefore, is not in the direction that would cause concerns about contamination of our dependent variable due to sectoral cyclical unemployment or structural change. If anything, trade-induced layoffs seems to have been mildly lower, not higher, during periods where we might be worried about outside sources of unemployment. We speculate that this result may change if we move to a more disaggregated level of sectoral analysis. Second, and more important, we see that our main results are robust to the introduction of 'Sectoral employment': All coefficient estimates remain significant and their magnitudes do not change significantly.

Next, we control for firm exit. Guided by theory, we would expect that, because trade-induced firm exit would cause the least productive non-exporting firms to lay off all of their workers (not just some of them), not accounting for firm exit should work against our results (which say that less productive non-exporters lay off fewer workers than more productive non-exporters), rather than in favor of them. In order to perform the empirical analysis, and in line with the literature,[33] we looked through the Compustat data and identified firms that have filed for Chapter 7 or Chapter 11 bankruptcy as well as firms that exited for other reasons excluding mergers or private acquisitions. According to our calculations during the 1980-2005 period, 0.2% of the firms filed for Chapter 7, 0.42% of the firms filed for Chapter 11, and 6.65% of the firms exited the sample for other reasons. We construct a new variable, ($EXIT\_RATE$), as the percentage of firms with an exit status in a given sector in a year, and we add this new covariate, along with sector-level employment, as an additional control variable to our main specifications. Estimation results from columns (4)-(6) of Table 2 reveal that variation in the the firm exit rate does not seem to affect trade-induced layoffs: The coefficient estimate on $EXIT\_RATE$ is not significant and none of our main results are affected by the introduction of the additional control. A possible explanation is that firms exit the sample due to other reasons besides trade, but the data does not allow us to verify whether these firm exits are due to trade-related reasons.

We also attempt to control for the possibility that our measure of layoff may be contaminated by cyclical layoffs at the firm level. In order to test for this concern,

[33]Please see Duffie, D., L. Saita and K. Wang (2007) "Multi-period corporate default prediction with stochastic covariates Journal of Financial Economics, vol. 83, p. 635-665 and Corbae D. and P. D'Erasmo (2014) "Reorganization or Liquidation: Bankruptcy Choice and Firm Dynamics."

we introduce the percentage change in firm employment as an additional covariate in our main specifications. Estimation results, which correspond to our main estimates from columns (5)-(7) of Table 1, are reported in columns (7)-(9) of Table 2. Once again, we see that our main results are robust to the inclusion of the new control. All coefficient estimates remain significant and their magnitudes are not statistically different. In addition, to the extent that changes in firm-level employment may be significantly correlated with trade-induced layoffs, as in column (7), this effect again is not in the direction that would cause concern about our dependent variable. In sum, we believe that this experiment demonstrates that, even though workers laid off for cyclical reasons (or other non-trade-related reasons) have every reason to file for TAA benefits, our findings are not driven by cyclical economic conditions.

Next, we experiment with two alternative dependent variables. First, we replace our main dependent variable, the logarithm of trade-induced layoffs 'log(layoffs)', with the logarithm of relative trade-induced layoffs 'log(layoffs/(layoffs+employment))', or "relative layoffs". Estimation results, which correspond to our most preferred specifications from columns (5)-(7) of Table 1, are reported in the first three columns of Table 3. Overall, the new coefficient estimates of the main variables are consistent with and remarkably close to our main findings. The only estimate that changes is the one of the $SIZE$ covariate. The explanation for the stable estimates on the main independent variables is that we already control for firm employment with our $SIZE$ variable. This is also the reason why the estimate on $SIZE$ switches sign and changes in magnitude in the new specification. Nonetheless, this result clarifies that our results are robust to other ways of specifying trade-induced layoffs.

Finally, we use percent change in firm employment as a dependent variable and we re-estimate our main regressions. Because our dependent variable is now the growth rate in number of employees, we expect to obtain opposite signs on the coefficient estimates compared to our main estimation results, which are based on (trade-induced) layoffs. Our results appear in columns (4)-(6) of Table 3. Three main findings stand out. First, the estimates from column (3) are statistically significant and in accordance with our expectations. Second, these estimates are less precise as compared to our main results. Third, the estimates from columns (5) and (6) are mostly insignificant. Our explanation for the more noisy estimates in column (4) and for the insignificant results in columns (5) and (6) is that the overall change in labor at the firm level might be due to many reasons beside trade. As a last check, we estimate or main specifications but only using IV methods. The idea is to employ the whole sample and we control explicitly for the outcome of the certification process by including the variable $SUFFER$ directly in the estimating equation. Estimation results are reported in columns (7)-(9) of Table 3. Once again, we see that most of the coefficient estimates are not statistically significant, which is in accordance with the results and analysis from columns (4)-(6). Overall, while we do see some evidence of a relationship between our main explanatory variables and changes in overall firm employment, we view these links as weak and we think that these results emphasize the uniqueness and appropriateness of our data on trade-induced layoffs.

6 Conclusion

The main contribution of our work is twofold: First, we use a novel data set with verified observations of trade-induced layoffs, based on petitions for Trade Adjustment Assistance filed with the U.S. Department of Labor, which grants us a unique opportunity to directly test model predictions regarding the effects of trade liberalization on firm-level layoffs due to trade. We find that patterns of trade-induced layoffs are broadly consistent with the predictions of the Melitz (2003) heterogeneous firms theory – the number of trade-induced layoffs increases with firm productivity for non-exporting firms but decreases with firm productivity for exporting firms; Second, we highlight some important ways in which the data suggests some improvements to the basic theory. For example, the fact that exporting firms incur trade-induced layoffs implies that exporting firms lay off some workers who work in production for the domestic market. In addition, our estimates imply within-firm reallocation of workers from domestic to export production. Finally, we find that, even after controlling for productivity, larger firms lay off more workers due to trade competition.

A central feature of our results is the role played by firm productivity. In our initial estimates, which abstract from export status, the effect of a given tariff reduction seems to be more pronounced at more productive firms. We motivate this initial specification by assuming that exporting firms lay off workers involved in production for the domestic market. When we explicitly consider the direct partial effect of firm productivity on layoffs, however, we do not find that more productive firms lay off more workers due to trade than less productive firms. We explain this discrepancy by considering an alternate specification in which the role played by firm productivity differs based on export status. We then find that trade-induced layoffs are increasing in productivity for non-exporters, but decreasing in productivity for exporters. A reasonable interpretation in light of the model is that exporters shift at least some of their domestic workers towards export production.

An interesting extension of our paper will be to test whether and how our findings differ for industries with comparative advantage as opposed to industries with comparative disadvantage. For example, Bernard et al. (2007), extend Melitz's (2003) model to allow for firm heterogeneity in a comparative advantage setting. They show that the zero-profit productivity cutoff increases in both types of industries but the increase is bigger in the sectors with comparative advantage. In addition, the export productivity cutoff is closer to the zero productivity cutoff in sectors with comparative advantage. In regard to the labor market, their findings suggest that trade liberalization results in simultaneous job creation and job destruction in all industries, but comparative disadvantage industries exhibit net job destruction while comparative advantage industries experience net job creation. Our data allows for various tests of their model, depending on industry type.

Acknowledgements

We are indebted to Fabio Ghironi for guidance and encouragement. We are grateful to Theo Eicher, Editor of the European Economic Review, and to three anonymous referees for their thoughtful comments and constructive suggestions. We also wish to thank Delina Agnosteva, James Anderson, Christopher Baum, Marissa Ginn, Jean Imbs, Paul Jensen, Luisa Lambertini, Vibhas Madan, Phillip McCalman, Marc Melitz, Alexandre Skiba, Costas Syropoulos, and Mathias Thoenig for productive suggestions and discussions. We also benefitted from comments of seminar participants at the Doctoral Meeting of Montpellier 1st Edition, the R@BC Graduate Workshop at Boston College, the 2008 Southern Economic Association meetings in Washington, D.C., and the 2009 meetings of the European Trade Study Group (ETSG) in Rome. Special thanks are due to Timothy Theberge and Cristian Vidrascu from the Employment and Training Administration of the U.S. Department of Labor for helping us with the TAA data. The paper does not necessarily reflect the views of the Federal Reserve Bank of Richmond or the Federal Reserve System. As usual, all errors are ours.

References

Richard Baldwin. Heterogeneous firms and trade: Testable and untestable properties of the melitz model. *NBER Working Paper no. 11471*, 2005.

Eric J. Bartelsman, Randy A. Becker, and Wayne B. Gray. Nber-ces manufacturing industry database. *NBER Working Paper no. 205*, 2001.

Andrew B. Bernard, J. Bradford Jensen, and Peter K. Schott. Survival of the best fit: Low wage competition and the (uneven) growth of us manufacturing plants. *Journal of International Economics*, 68:219–237, 2006.

Andrew B. Bernard, Stephen J. Redding, and Peter K. Schott. Comparative advantage and heterogeneous firms. *Review of Economic Studies*, 74:31–66, 2007.

Paula Bustos. Multilateral trade liberalization, exports and technology upgrading: Evidence on the impact of mercosur on argentinean firms. *Manuscript*, 2006.

Benjamin Collins. Trade adjustment assistance for workers. *Congressional Research Service*, 2012.

A. Kerem Cosar, Nezih Guner, and James Tybout. Firm dynamics, job turnover, and wage distributions in an open economy. *IZA Discussion Paper No. 7718*, 2013.

Donald R Davis and James Harrigan. Good jobs, bad jobs, and trade liberalization. *Journal of International Economics*, 84(1):26–36, 2011.

David J. Denis, Diane K. Denis, and Keven Yost. Global diversification, industrial diversification, and firm value. *The Journal of Finance*, 57(5):1951–1979, 2002.

Hartmut Egger and Udo Kreickemeier. Firm heterogeneity and the labor market effects of trade liberalization*. *International Economic Review*, 50(1):187–216, 2009.

Robert C. Feenstra. Nber trade database, disk1: U.s. imports, 1972-1994: Data and concordances. *NBER Working Paper no. 5515*, 1996.

Gabriel Felbermayr, Julien Prat, and Hans-Jörg Schmerer. Globalization and labor market outcomes: Wage bargaining, search frictions, and firm heterogeneity. *Journal of Economic Theory*, 161(1):39–73, 2011a.

Gabriel Felbermayr, Julien Prat, and Hans-Jörg Schmerer. Trade and unemployment: What do the data say? *European Economic Review*, 55(6):741–758, 2011b.

Robert E. Hall. Job loss, job finding, and unemployment in the u.s. economy over the past fifty years. *NBER Working Paper no. 11678*, 2005.

James J. Heckman. Sample selection bias as a specification error. *Econometrica*, 47: 153–161, 1979.

Elhanan Helpman and Oleg Itskhoki. Labour market rigidities, trade and unemployment. *The Review of Economic Studies*, 77(3):1100–1137, 2010.

Elhanan Helpman, Oleg Itskhoki, and Stephen Redding. Inequality and unemployment in a global economy. *Econometrica*, 78(4):1239–1283, 2010.

Elhanan Helpman, Oleg Itskhoki, Marc-Andreas Muendler, and Stephen Redding. Trade and inequality: From theory to estimation. *NBER Working Paper no. 17991*, 2014.

Gueorgui Kambourov. Labor market regulations and the sectoral reallocation of workers: The case of trade reforms. *Review of Economic Studies*, 76(4), 2009.

Illenin O. Kondo. *Trade Reforms, Foreign Competition, and Labor Market Adjustments in the U.S.* Board of the Governors of the Federal Reserve System (U.S.), 2013.

J. Konings and H. Vandenbussche. Heterogenous response of firms to trade protection. *Journal of International Economics*, 76:371–383, 2008.

Christopher Laincz, Xenia Matschke, and Yoto V. Yotov. Trade adjustment assistance and political influence. *Manuscript*, 2014.

Christopher Magee. Administered protection for workers: an analysis of the trade adjustment assistance program. *Journal of International Economics*, 53(1):105–125, 2001.

Marc J Melitz and Stephen J Redding. Heterogeneous firms and trade. *Handbook of International Economics*, 4:1, 2014.

Mark J. Melitz. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71:1695–1725, 2003.

Naércio Aquino Menezes-Filho and Marc-Andreas Muendler. Labor reallocation in response to trade reform. *NBER Working Paper no. 17372*, 2011.

Nina Pavcnik. Trade liberalization, exit, and productivity improvements: Evidence from chilean plants. *Review of Economic Studies*, 69:245–276, 2002.

A. Petrin and James Levinsohn. Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, 70(2):317–342, 2003.

A. Petrin, B. P. Poi, and James Levinsohn. Production function estimation in stata using inputs to control for unobservables. *The Stata Journal*, 4(2):113–123, 2004.

Daniel Trefler. The long and short of the canada-us free trade agreement. *The American Economic Review*, 94(4):870–895, 2004.

Yoto V. Yotov. Trade-induced unemployment: How much do we care? *Review of International Economics*, 18(5):972–89, 2010.

Yoto V. Yotov. Trade adjustment, political pressure, and trade protection patterns. *Economic Inquiry*, 51(3):1867–1885, 2013.

Table 1: Trade Liberalization, Productivity and Layoffs

	(1) BASE	(2) EMPL	(3) IV	(4) POLIT	(5) SLCT	(6) LIBER	(7) EXPRT
L.T*TFP	17.217***	15.952***	27.965***	28.028***	28.383***		
	(6.008)	(5.784)	(9.027)	(8.979)	(7.502)		
T*TFP	-25.509***	-24.683***	-42.415***	-41.738***	-35.646***		
	(6.710)	(6.557)	(11.216)	(11.192)	10.409		
SIZE		0.125***	0.124***	0.120***	0.129***	0.135***	0.140***
		(0.042)	(0.041)	(0.040)	(0.030)	(0.031)	(0.031)
UNION		0.645***	0.601***	0.607***	0.541***	0.441***	0.470***
		(0.123)	(0.124)	(0.127)	(0.136)	(0.140)	(0.139)
POLIT				-0.027			
				(0.105)			
TFP						-0.871	73.554***
						(8.266)	(28.507)
LIBER						32.378***	30.381***
						(8.916)	(8.874)
EXP							78.391***
							(29.225)
TFP*EXP							-78.758***
							(29.323)
SUFFER							
POLIT					-0.214***	-0.220***	-0.220***
					(0.070)	(0.072)	(0.072)
UNION					0.116	0.191*	0.191*
					(0.099)	(0.101)	(0.101)
TARIFF					-21.543***	-30.285***	-30.285***
					(2.245)	(2.693)	(2.693)
ΔIMP					0.320***	0.408***	0.408***
					(0.094)	(0.098)	(0.098)
LABOR_COST					-0.013	-0.041*	-0.041*
					(0.021)	(0.022)	(0.022)
Mills Ratio					-0.589*	-0.925***	-0.868***
λ					(0.352)	(0.233)	(0.233)
N	1259	1259	1236	1236	2145	2067	2067
Chi2							
R^2, $Wald-\chi^2$	0.198	0.228			348.91	328.48	342.13
UnderId			0.000	0.000			
OverId			0.310	0.307			

This table reports our main estimation results. The dependent variable is always the logarithm of firm layoffs. Column (1) introduces the main covariates. Column (2) adds control variables. Column (3) reports IV estimates, which account for potential endogeneity. Columns (4) and (5) control for selection. Column (6) estimates an alternative to our main specification. Finally, column (7) allows for different outcomes depending on export status. The numbers in parenthesis are standard errors. *, **, and *** denote coefficients significantly different from zero at the 0.10, 0.05, and 0.01 level, respectively. Each estimation includes SIC-3 dummies and the errors are clustered at the firm-industry level. The estimates of the fixed effects, including the constant, are omitted for brevity. See text for further details.

Table 2: Sensitivity Experiments: Additional Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Sector Employment			Exit Rate			%Δ Firm Employment		
	SLCT	LIBER	EXPRT	SLCT	LIBER	EXPRT	SLCT	LIBER	EXPRT
L.T*TFP	28.490***			28.434***			29.490***		
	(7.511)			(7.511)			(7.458)		
T*TFP	-36.823***			-37.073***			-39.452***		
	(10.559)			(10.543)			(10.511)		
SIZE	0.125***	0.134***	0.137***	0.120***	0.131***	0.135***	0.118***	0.127***	0.131***
	(0.030)	(0.031)	(0.031)	(0.030)	(0.032)	(0.032)	(0.030)	(0.031)	(0.031)
UNION	0.517***	0.415***	0.441***	0.522***	0.417***	0.442***	0.576***	0.445***	0.441***
	(0.137)	(0.141)	(0.140)	(0.137)	(0.142)	(0.140)	(0.136)	(0.140)	(0.140)
Sector employment	0.002**	0.001*	0.002**	0.002**	0.001*	0.002**	0.002*	0.001	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
TFP		-0.666	78.097***		-0.889	77.570***		-1.654	76.019***
		(8.234)	(28.683)		(8.277)	(28.750)		(8.213)	(28.646)
LIBER		32.302***	30.137***		32.247***	30.083***		32.768***	30.612***
		(8.927)	(8.884)		(8.937)	(8.892)		(8.909)	(8.880)
EXP			82.894***			82.486***			81.746***
			(29.415)			(29.423)			(29.381)
TFP*EXP			-83.247***			-82.840***			-82.106***
			(29.512)			(29.521)			(29.478)
EXIT RATE				-0.113	-0.071	-0.052			
				(0.168)	(0.177)	(0.176)			
% Change in Employment							0.003*	0.003	0.003
							(0.002)	(0.002)	(0.002)
SUFFER									
POLIT	-0.214***	-0.220***	-0.220***	-0.214***	-0.220***	-0.220***	-0.214***	-0.220***	-0.220***
	(0.070)	(0.072)	(0.072)	(0.070)	(0.072)	(0.072)	(0.070)	(0.072)	(0.072)
UNION	0.116	0.191*	0.191*	0.116	0.191*	0.191*	0.116	0.191*	0.191*
	(0.099)	(0.101)	(0.101)	(0.099)	(0.101)	(0.101)	(0.099)	(0.101)	(0.101)
TARIFF	-21.543***	-30.285***	-30.285***	-21.543***	-30.285***	-30.285***	-21.543***	-30.285***	-30.285***
	(2.245)	(2.693)	(2.693)	(2.245)	(2.693)	(2.693)	(2.245)	(2.693)	(2.693)
ΔIMP	0.320***	0.408***	0.408***	0.320***	0.408***	0.408***	0.320***	0.408***	0.408***
	(0.094)	(0.098)	(0.098)	(0.094)	(0.098)	(0.098)	(0.094)	(0.098)	(0.098)
LABOR_COST	-0.013	-0.041*	-0.041*	-0.013	-0.041*	-0.041*	-0.013	-0.041*	-0.041*
	(0.021)	(0.022)	(0.022)	(0.021)	(0.022)	(0.022)	(0.021)	(0.022)	(0.022)
Mills Ratio									
λ	-0.658*	-0.984***	-0.938***	-0.639*	-0.987***	-0.940***	-0.570	-0.976***	-0.930***
	(0.355)	(0.236)	(0.237)	(0.355)	(0.236)	(0.237)	(0.357)	(0.236)	(0.237)
N	2145	2067	2067	2145	2067	2067	2145	2067	2067

The results in this table reproduce our main estimates from columns (5)-(7) of Table 1 with additional control variables. The dependent variable is always the logarithm of firm layoffs. In columns (1)-(3) we add 'Sector employment.' In columns (4)-(6) we introduce 'EXIT RATE.' Finally, in columns (7)-(9), we control for the percentage change in firm employment, '% Change in Employment'. The numbers in parenthesis are standard errors. *, **, and *** denote coefficients significantly different from zero at the 0.10, 0.05, and 0.01 level, respectively. Each estimation includes SIC-3 dummies and the errors are clustered at the firm-industry level. The estimates of the fixed effects, including the constant term, are omitted for brevity. See text for further details.

Table 3: Sensitivity Experiments: Alternative Dependent Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Relative Layoffs				%Δ in Firm Employment			
	SLCT	LIBER	EXPRT	SLCT	LIBER	EXPRT	IV	LIBER-IV	EXPRT-IV
L.T*TFP	28.114***			-387.010***			-167.528		
	(7.375)			(128.269)			(156.016)		
T*TFP	-35.164***			964.905***			327.099*		
	(10.235)			(183.140)			(191.251)		
SIZE	-0.838***	-0.831***	-0.827***	2.308***	2.416***	2.349***	2.745***	2.580***	2.622***
	(0.029)	(0.030)	(0.030)	(0.541)	(0.504)	(0.509)	(0.604)	(0.659)	(0.662)
UNION	0.534***	0.437***	0.467***	-1.169	0.655	0.712	0.295	-0.195	0.018
	(0.134)	(0.137)	(0.136)	(2.499)	(2.276)	(2.278)	(2.472)	(2.484)	(2.509)
TFP		0.614	78.265***		362.138**	607.001		297.795	1207.089*
		(8.120)	(27.992)		(144.783)	(490.014)		(316.725)	(640.312)
LIBER		32.004***	29.945***		-180.394	-177.982		76.163	69.580
		(8.755)	(8.715)		(149.950)	(150.101)		(150.873)	(151.489)
EXP			81.897***			260.434			950.067
			(28.697)			(504.020)			(714.283)
TFP*EXP			-82.238***			-258.386			-952.233
			(28.793)			(505.638)			(717.080)
SUFFER							-1.350	-1.733	-1.596
							(1.511)	(1.637)	(1.598)
SUFFER									
POLIT	-0.214***	-0.220***	-0.220***	-0.214***	-0.220***	-0.220***			
	(0.070)	(0.072)	(0.072)	(0.070)	(0.072)	(0.072)			
UNION	0.116	0.191*	0.191*	0.116	0.191*	0.191*			
	(0.099)	(0.101)	(0.101)	(0.099)	(0.101)	(0.101)			
TARIFF	-21.543***	-30.285***	-30.285***	-21.543***	-30.285***	-30.285***			
	(2.245)	(2.693)	(2.693)	(2.245)	(2.693)	(2.693)			
ΔIMP	0.320***	0.408***	0.408***	0.320***	0.408***	0.408***			
	(0.094)	(0.098)	(0.098)	(0.094)	(0.098)	(0.098)			
LABOR_COST	-0.013	-0.041*	-0.041*	-0.013	-0.041*	-0.041*			
	(0.021)	(0.022)	(0.022)	(0.021)	(0.022)	(0.022)			
Mills Ratio									
λ	-0.592*	-0.905***	-0.853***	-25.378***	-0.689	-1.358			
	(0.346)	(0.229)	(0.229)	(6.147)	(3.923)	(3.952)			
N	2145	2067	2067	2145	2067	2067	1898	1732	1732
Under-Id							0.000	0.000	0.000
Hansen J							0.491	0.059	0.052

The results in this table reproduce our main estimates from Table 1 with alternative dependent variables. The dependent variable in the first three columns is the relative layoffs, as defined in the text. The dependent variable in the remaining columns is the percentage change in firm employment. The numbers in parenthesis are standard errors. *, **, and *** denote coefficients significantly different from zero at the 0.10, 0.05, and 0.01 level, respectively. Each estimation includes SIC-3 dummies and the errors are clustered at the firm-industry level. The estimates of the fixed effects, including the constant term, are omitted for brevity. See text for further details.

Appendix

Proof of Proposition 1 Parts (a) and (b): Using Equation 2.3 for l^{ct} and its counter part for l^{tl} we can express the change in labor as:

$$l^{ct} - l^{tl} = (\sigma - 1) f \left[\left(\frac{1}{\varphi^{ct}} \right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}} \right)^{\sigma-1} \right] \varphi^{\sigma-1} \tag{6.1}$$

We know from theory that the zero profit productivity cutoff for domestic production increases after a country moves from costly trade to liberalized trade:

$$\begin{aligned} \varphi^{tl} &> \varphi^{ct} \\ \left(\frac{1}{\varphi^{tl}} \right)^{\sigma-1} &< \left(\frac{1}{\varphi^{ct}} \right)^{\sigma-1} \\ 0 &< \left(\frac{1}{\varphi^{ct}} \right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}} \right)^{\sigma-1} \\ 0 &< (\sigma - 1) f \left[\left(\frac{1}{\varphi^{ct}} \right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}} \right)^{\sigma-1} \right] \varphi^{\sigma-1} = l^{ct} - l^{tl} \qquad (6.2) \end{aligned}$$

The positive sign indicates that the number of workers employed under costly trade was higher than the number of workers employed under trade liberalization, i.e. there have been labor layoffs for domestic production. Additionally more liberalization will imply a larger discrepancy between the zero profit productivity cutoffs, and hence a higher number of layoffs. Also, taking the derivative of equation 6.1 with respect to φ:

$$\frac{\partial (l^{ct} - l^{tl})}{\partial \varphi} = (\sigma - 1)^2 f \left[\left(\frac{1}{\varphi^{ct}} \right)^{\sigma-1} - \left(\frac{1}{\varphi^{tl}} \right)^{\sigma-1} \right] \varphi^{\sigma-2} > 0, \tag{6.3}$$

we find that if a firm is more productive it lays off more workers.

Part (c): For the change in labor for export production:

$$\begin{aligned} nl_x^{ct} - nl_x^{tl} &= nr_x^{ct}(\varphi)\frac{\sigma - 1}{\sigma} - nr_x^{tl}(\varphi)\frac{\sigma - 1}{\sigma} \\ &= n(1 + t^{ct})^{1-\sigma} r_d^{ct}(\varphi)\frac{\sigma - 1}{\sigma} - n(1 + t^{tl})^{1-\sigma} r_d^{tl}(\varphi)\frac{\sigma - 1}{\sigma} \qquad (6.4) \\ &= n(1 + t^{ct})^{1-\sigma}(\sigma - 1) f_x \left(\frac{1 + t^{ct}}{\varphi_x^{ct}} \right)^{\sigma-1} \varphi^{\sigma-1} \\ &\quad - n(1 + t^{tl})^{1-\sigma}(\sigma - 1) f_x \left(\frac{1 + t^{tl}}{\varphi_x^{tl}} \right)^{\sigma-1} \varphi^{\sigma-1} \\ nl_x^{ct} - nl_x^{tl} &= n(\sigma - 1) f_x \left[\left(\frac{1}{\varphi_x^{ct}} \right)^{\sigma-1} - \left(\frac{1}{\varphi_x^{tl}} \right)^{\sigma-1} \right] \varphi^{\sigma-1} \qquad (6.5) \end{aligned}$$

By using the relationship $\varphi_x^{tl} > \varphi_x^{tl}$, we can conclude that $nl_x^{ct} - nl_x^{tl} < 0$, i.e. there are gross hires for export production. Similar to the previous part we see that more liberalization will imply a larger change in the zero profit export cutoff and more labor hires. Taking the derivative of equation 6.5 with respect to φ:

$$\frac{\partial(l^{ct}-l^{tl})}{\partial\varphi} = n(\sigma-1)^2 f_x \left[\left(\frac{1}{\varphi_x^{ct}}\right)^{\sigma-1} - \left(\frac{1}{\varphi_x^{tl}}\right)^{\sigma-1}\right]\varphi^{\sigma-2} < 0, \tag{6.6}$$

we find that the more productive export firms will be hiring more workers.

Part (d): To see the overall effect of trade liberalization on labor layoffs for exporters:

$$\begin{aligned} l^{ct}-l^{tl} &= \frac{\sigma-1}{\sigma}\left[1+n(1+t^{ct})^{1-\sigma}\right] r_d^{ct}(\varphi) - \frac{\sigma-1}{\sigma}\left[1+n(1+t^{tl})^{1-\sigma}\right] r_d^{tl}(\varphi) \\ &= (\sigma-1)\left[1+n(1+t^{ct})^{1-\sigma}\right] f\left(\frac{1}{\varphi^{ct}}\right)^{\sigma-1}\varphi^{\sigma-1} - \\ &\qquad (\sigma-1)\left[1+n(1+t^{tl})^{1-\sigma}\right] f\left(\frac{1}{\varphi^{tl}}\right)^{\sigma-1}\varphi^{\sigma-1} \\ &= (\sigma-1)f\left[\frac{1+n(1+t^{ct})^{1-\sigma}}{(\varphi^{ct})^{\sigma-1}} - \frac{1+n(1+t^{tl})^{1-\sigma}}{(\varphi^{tl})^{\sigma-1}}\right]. \end{aligned} \tag{6.7}$$

As shown in the appendix of Melitz (2003) since $\frac{\partial\left[\frac{1+n(1+t)^{1-\sigma}}{\varphi^{\sigma-1}}\right]}{\partial t} < 0$, the expression in square brackets is negative. Notice that $t^{ct} > t^{tl}$, $\frac{1+n(1+t^{ct})^{1-\sigma}}{(\varphi^{ct})^{\sigma-1}} < \frac{1+n(1+t^{tl})^{1-\sigma}}{(\varphi^{tl})^{\sigma-1}}$, and $l^{ct}-l^{tl} < 0$ and exporters hire workers. Once again, we see that the larger the change in tariffs, the larger its effect will be on the net labor hires for exporters. Moreover, taking the derivative of equation 6.7:

$$\frac{\partial l^{ct}-l^{tl}}{\varphi} = (\sigma-1)^2 f\left[\frac{1+n(1+t^{ct})^{1-\sigma}}{(\varphi^{ct})^{\sigma-1}} - \frac{1+n(1+t^{tl})^{1-\sigma}}{(\varphi^{tl})^{\sigma-1}}\right]\varphi^{\sigma-2} > 0, \tag{6.8}$$

we find that if a firm is more productive it hires more workers.

Table 4: **Descriptive Statistics**

	Suffer=1				Suffer=0			
	Mean	Std. Dev.	P(25)	P(75)	Mean	Std. Dev.	P(25)	P(75)
LAID OFF WORKERS	176.908	421.875	27	184	233.519	634.406	25	200
TFP	0.999	0.007	0.996	1.002	1.000	0.008	0.997	1.003
TARIFF	0.026	0.032	0.005	0.036	0.033	0.041	0.007	0.0457
LIBER	0.002	0.007	-0.000	0.002	0.002	0.009	-0.000	0.003
SIZE	22989.91	30870.77	3411	29000	32695.65	40770.91	4800	43000
LABOR_COST	824.724	1263.445	91.636	960.085	1010.319	1441.828	138.405	1250.752
IMPORTS	3.179	2.443	1.371	4.457	2.219	2.161	0.662	3.304
POLIT	0.547	0.498	0	1	0.719	0.450	0	1
EXPORT	0.912	0.284	1	1	0.946	0.226	1	1
N	1158				905			