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Abstract: Globalization affects the mix of jobs available in an economy and the rate at which workers gain skills. We develop a model in which firms differ in terms of productivity and workers differ in skills, and use the model to examine how globalization affects the wage distribution and the career path of workers as they move up the jobs ladder. We calibrate the model using many of the same parameters and targeting the same moments of the US economy as Melitz and Redding (2015) and then investigate the impact of globalization. Our results indicate that although falling trade costs results in greater wage inequality, it also leads to a wider path up the jobs ladder and less time spent in entry level jobs.

JEL: F10, F20, J30
Keywords: Job Ladders, Globalization, Wages, Inequality, Export

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Introduction

The impact of globalization on the labor market is one of the most heavily researched and hotly debated topics in economics. In the academic arena, researchers primarily focus on connecting globalization with wage inequality, using this connection as a way to identify those that benefit and those that are harmed by globalization. A narrow focus on wages may be misleading, however, in that jobs carry with them more than just a wage. Workers gain skills while carrying out their duties and the skills they acquire may open up new paths for them as they move from job to job.[1] An engineer at Ford gains valuable experience in the auto industry that may result in a higher paying job with GM or Chrysler. Alternatively, a manager at a firm that exports its products to China may be a prime target for another firm that is hoping to break into the Chinese market. Thus, the rate at which workers gain skills, the types of skills they acquire and the rate at which they move up the jobs ladder can play a large role in determining lifetime earnings.[2] By impacting the level of international engagement by firms and the types of jobs available, globalization can impact the skill sets that workers acquire and thus, their career paths. And, while the literature on the impact of globalization on wage inequality is vast and growing (see Harrison, McLaren and McMillan 2011 and Helpman 2017 for surveys), not much attention has been paid to the link between globalization and these dynamic properties of the labor market.[3] The purpose of this paper is to provide a framework in which to examine such issues, with attention focused on the link between globalization and economic mobility.

We examine how globalization affects economic mobility in a dynamic heterogeneous firm model of trade in which workers gain skills on the job and move from job to job as their careers progress. There

[1] A typical worker holds a large number of jobs while young, before transitioning to a more stable employment pattern with maturity. However, even prime-age adults transition from job to job as their careers progress – the average duration of a job in the US is about 8 years, with a median duration slightly lower than that. Moreover, job stability has been declining. For example, average job tenure for males at age 50 has declined from 13.6 years in the 1970s to 11.8 years in the early 2000s (classic references on job stability are Hall 1982 and Farber 1994, 1998 – Farber 2010 provides a survey of the literature).

[2] For an excellent discussion the importance of economic mobility in determining lifetime earnings see Bernhardt, Morris, Handcock and Scott (2001).

[3] Recent papers that focus on labor market dynamics and trade include Artuc, Chaudhuri and McLaren (2010), Dix-Carnerio (2014), Cosar, Guner and Tybout (2014), Felbermayr, Impullitti and Prat (2018) and Caliendo, Dvorkin and Parro (2019). These papers, however, have a decidedly different focus in that they examine how the economy adjusts to a new equilibrium following a trade shock. Our focus is on how a trade shock affects the career paths of workers.

are two types of skills that matter for productivity – the ability to work with the appropriate technology, which we call "basic experience", and the ability to facilitate international commerce, which we call "international experience". We assume that firms cannot directly observe the skills embodied in a worker, but they can observe each recruit's employment history. Firms differ in productivity and self-select into different recruiting networks based on their own productivity and the signals embedded in each recruit's employment history. Some firms hire inexperienced workers and pay a low wage while others poach workers with experience by offering a higher wage. Firms also differ in their level of international engagement with only high productivity firms able to cover the costs of exporting. Since a firm's trade costs depend on the level of international experience embedded in their workforce, international experience is valuable to firms that export a large share of their output. Our goal is to examine how globalization affects the distribution of wages offered by firms and the rates at which workers move up the jobs ladder as they gain skills. This provides us with a more complete picture of how globalization affects the labor market experience of workers.

Our framework is motivated by the empirical findings of Haltiwanger, Hyatt, Kahn and McEntarfer (2018) that firms with different levels of productivity tend to use different strategies to fill their vacancies. Their study focuses on job flows across firms that offer different wages along the jobs ladder. It reveals that firms that are low on the jobs ladder tend to hire new workers from the pool of unemployed, while firms at the top tend to poach workers from lower paying firms. We posit that one of the main reasons for this is that high-productivity, high-wage firms are concerned about the skills that workers carry with them. By recruiting workers that have been able to hold steady jobs, high-wage firms can be confident that they are adding workers that have proven to be reliable and effective. If these workers are poached from firms within the same industry, they are also likely to be more productive, since they have experience with the technology that the firm is using.

Knowledge of and experience with the production process is only one aspect of productivity that may matter for firms. By poaching workers from exporters, a firm may be able to build a workforce that includes skills that may lower trade costs. The notion that internationally engaged firms hire workers with

international experience to lower trade costs is consistent with recent empirical findings. For example, Labanca, Molina and Muendler (2014) find that as firms prepare to export, they poach workers from other exporters. This leads to deeper market penetration by the poacher and reduced market penetration by the firm that loses the worker. In addition, Mion, Opromolla and Sforza (2017) show that export experience gained by a manager at a previous firm leads to better export performance by the worker's current employer and a large wage premium for the manager.

To formalize ideas, in section 2 we develop a model of a jobs ladder in which firms differ in productivity and workers differ in the skills that they have acquired. The firm side is modeled as in Melitz (2003) in that each firm draws a productivity parameter after paying a sunk cost of entry. Worker productivity is determined by experiences on the job and imperfectly observable factors. All workers begin life inexperienced and start their climb up the jobs ladder with an entry level job that pays a low wage. They gain "basic skill" via a Poisson and this increases their sector-specific productivity, preparing them to move to the next rung on the ladder. Random skill acquisition captures the idea that some workers pick up the production process quickly while others never seem to grasp the essential details. Thus, some workers see their productivity rise right away, while others remain at their initial low-productivity rate for a very long time. However, without additional information, firms cannot distinguish employed workers with basic experience from their counterparts that are still inexperienced. To obtain this information, firms can screen workers at a cost. This means that firms face a trade-off. They can offer a low wage and hire workers without screening, so that some share of their workforce will be inexperienced. Alternatively, firms can offer a higher wage, poach workers from low-wage firms and screen for basic experience. These firms bear higher costs in filling out their workforce, but their employees will be more productive.

Workers go through a similar process to gain international experience. If they are employed by an exporter, they gain international experience through a Poisson process, and the firm's trade costs are assumed to be a decreasing function of the fraction of its workforce that has international experience. As with basic experience, international experience cannot directly be observed, but firms can use a costly screening process to identify those workers that have acquired it.

In equilibrium, active firms self-select into four categories, defined by the wage they pay, the workers they hire and their level of international engagement. Low-productivity firms hire inexperienced workers, pay a low wage and serve only their domestic market. While employed at these entry-level firms, some workers gain basic experience, which makes them eligible to apply for higher paying jobs. Medium-productivity firms pay a higher wage and poach workers from entry-level firms. To ensure that these workers have basic experience, these firms screen potential employees before hiring them. Among this group of medium-productivity firms, those at the low-end of the productivity scale do not earn enough revenue to cover the costs associated with exporting, so they sell all their output domestically. The remaining medium-productivity firms export a portion of their output, enabling some of their workers to gain international experience. Finally, high productivity firms pay the highest wage, poach workers from medium-productivity exporters, screen for international experience and export a portion of their output.[4]

We assume that opportunities to move up the ladder arrive randomly and that changing jobs is costly. The latter assumption captures the notion that a new job might require movement to a new location, disrupt family or social networks, and/or require adaptation to a new routine. We aggregate these costs into a single worker-specific measure that is randomly drawn at the time that the job opportunity becomes available. The worker accepts the job offer if and only if the increase in expected lifetime income exceeds the cost of moving (this method of modelling worker movement across jobs follows Artuc, et al 2010).

In section 3, we analyze a symmetric trade model in which globalization reduces variable trade costs. As trade costs fall, firms reconsider their decisions with the most important changes coming from medium-productivity firms. Amongst this class, firms that were already internationally engaged expand their exports and see their revenues rise enough to enable them to become high-wage firms. Their lower-productivity non-exporting counterparts are harmed by an inflow of imports, forcing them to become low-

[4] We know of no study of the role that international engagement plays in determining firms' recruiting strategies, so it is difficult to provide empirical support for our assumptions along these lines. However, in our companion paper (Davidson, Heyman, Matusz, Sjoholm and Zhu 2019) we investigate this issue using matched worker-firm data from Sweden and find recruiting patterns that are consistent with our assumptions. For example, we find that compared to other firm groups, non-exporters are more likely to hire workers from other firms that do not export while high-export firms are more likely to hire workers from other high-export firms.

wage firms. Finally, higher-productivity non-exporters take advantage of the lower trade costs and begin to export. As a result, the employment share for high-wage firms increases, while the employment share for medium-productivity non-exporters falls. We then calibrate the model using well established parameter values from the literature (as in Melitz and Redding 2015), and show that the fall in trade costs increases wage inequality, with high-wage workers gaining more than their low-wage and medium-wage counterparts.

The shift in jobs from non-exporters towards exporters and the link between globalization and wage inequality are in line with what we would expect from a trade model with heterogeneous firms (e.g., Egger and Kreickemeier 2012; Helpman, Itskhoki and Redding 2010a,b or Sampson 2014).[5] The wage effects are also consistent with the empirical findings of Helpman, Itskhoki, Muendler and Redding (2017). However, in the context of our model, taken together these results have implications for the way in which workers move up the jobs ladder. To see this, note first that while the total number jobs associated with medium-productivity firms falls as trade becomes less costly, there is a shift in the make-up of those jobs. In particular, since some medium-productivity non-exporters start to export, it is possible for the number of medium-productivity exporters to rise. An increase in the number of medium-productivity exporters is important, since these are the jobs that provide workers with the skills needed to make it to the top of the jobs ladder. Thus, the change in the *composition* of the medium-productivity jobs can alter the path that allows workers to cap off their careers by landing the highest paying jobs in the economy. Our results indicate that globalization tends to increase economic mobility by widening the path up the jobs ladder for low-wage workers.[6] As a result, the increase in economic mobility moderates the rise in inequality by

[5] Although our results are consistent with these papers, the mechanism behind our results differs. We assume competitive labor markets, while Egger and Kreickemeier (2012) use a fair wage model and Helpman, et al (2010a,b) and Sampson (2014) assume labor market frictions and wage bargaining. In their settings, increased inequality comes from an increase in the export wage premium. In addition, in those models workers do not move from low-wage to high-wage jobs, so that low-wage workers always remain low-wage workers.

[6] Increased wage inequality provides another reason that economic mobility might rise with globalization. When an opportunity to move arises, a worker accepts the offer if the expected benefit from moving exceeds the cost of doing so. Since wage inequality increases as trade costs fall, the expected benefit from taking an offer from a higher-paying firm grows with globalization. Thus, an increase in wage inequality should reduce the expected duration jobs, implying that workers reach the top of the jobs ladder quicker. This mechanism is discussed in Section 3.

allowing low-wage workers to climb up the jobs ladder at a faster pace.[7]

The implication of our main result is that by focusing simply on the impact of globalization on wage inequality, either across or within industries, one can miss potentially important changes in labor market dynamics that impact expected lifetime earnings. Although falling trade costs may result in greater wage inequality, it can also lead to a wider path up the jobs ladder and to greater economic mobility, implying that workers spend less time in entry level jobs.

Our model yields several testable hypotheses about the manner in which globalization affects the career paths of workers. In Section 4, we offer an interpretation of these results that has clear implications for the empirical approaches that we believe should be used to test these predictions. We also discuss an important theoretical extension of the model and the manner in which that extension may alter our basic results. Concluding remarks are offered in Section 5.

2. The Jobs Ladder

A. Types of Workers and Firms

We begin by providing an overview of the structure of the economy. Our model consists of a single industry with heterogeneous firms. At each point in time, there are $\mathcal{M}_d$ firms in the process of developing plans to enter the industry. Each developing firm draws a productivity measure (ϕ) as in Melitz (2003) and becomes active if it can at least break-even. We use $\mathcal{M}$ to denote the mass of active firms. Active firms produce output with labor as the only input.

The lifecycle of a worker is based on the model of perpetual youth (Blanchard 1985), with workers "dying" (exiting the workforce) at rate δ_w regardless of age. This is also the birth rate in a stationary economy. Upon birth, each worker makes a choice to become an entrepreneur, and spend their life

[7] Guner, Ruggieri and Tybout (2018) present an alternative model of the jobs ladder that has some overlap with ours (job poaching and on the job training) as well as significant differences (e.g., the way in which experience alters firm productivity and trade costs; unemployment and search frictions in the labor market). Most importantly, the main mechanism linking globalization to economic mobility differs. Their focus is on offshoring (which is not present in our model) and its impact on the outside option of workers. They find that offshoring slows down labor market turnover by limiting the outside options of workers and that this reduces economic mobility and slows wage growth. The main mechanism in our model is the way in which workers gain international experience and how that experience lowers trade costs for exporting firms. Globalization increases the number of firms that export, making it easier for workers to gain international experience and this can, in turn, lead to greater economic mobility.

developing new firms, or to begin climbing the jobs ladder. All workers are born with equal productivity but differ in entrepreneurial ability. Workers with sufficiently high entrepreneurial ability become developers. For now, we delay discussion of how this decision is made and how new firms are developed and focus instead on the novel feature of our model, the jobs ladder.

Workers enter the jobs ladder without experience but have the potential of gaining two kinds of experience (or skill) as they age. Basic experience lowers the cost of production, while international experience reduces the cost of exporting. Experience is not directly observable, but firms can pay a fixed cost to screen for either type of skill.

Labor markets are perfectly competitive, with wages adjusting to equate supply and demand in each sub-market and firms taking those wages as given. There are four market-clearing wages that make up the jobs ladder. We use w_l and w_h to represent the lowest and highest wages which are paid by the least productive and most productive firms. The two intermediate (or "medium") wages are paid by medium-productivity firms, only some of which export. We use w_x to represent the wage paid by medium-productivity exporters, and w_n to represent the wage paid by medium-productivity non-exporters. We choose unskilled labor as numeraire, therefore $w_l = 1$. We discuss the rank order of w_x and w_n below.

Firms can choose to hire only new labor market entrants, pay the low wage, and save the fixed cost of screening. Firms weigh the lower fixed cost against the fact that these inexperienced workers are relatively less productive, resulting in higher marginal cost. Using standard analysis, it is easy to show that this is the profit-maximizing strategy for the lowest productivity firms since their sales are too low to earn enough operating profit to cover the cost of screening. Using similar reasoning, it follows that firms can choose to screen for basic experience and pay one of the two medium wages (w_n or w_x), or they can screen for international experience as well and pay the high wage. In addition to choosing their screening strategy, firms choose whether to export. Following Melitz (2003), we assume a fixed cost of exporting so that only the most productive firms can afford to do so.

The firm's decision tree is illustrated in Figure 1. Firms are characterized by the wage that they pay and by whether they choose to export. In equilibrium, no low-wage firm exports and all high-wage

firms export. In contrast, some medium-wage firms export while others do not. We use the subscript l to represent all variables associated with low-wage firms; the subscript h to represent variables associated with high-wage firms; the sub-script n to identify variables related to medium-wage non-exporters; and the subscript x to identify those associated with medium-wage exporters.

We model the acquisition of basic experience as a Poisson process (some inexperienced workers catch on faster than others; some never catch on), using s_b to represent the rate at which workers gain this experience. In a similar way, workers with only basic experience may acquire international experience via an independent Poisson process with at rate s_i. Since international experience can only be gained by working for an exporter, $s_i = 0$ for all workers employed by non-exporters.

The transition rates s_b and s_i are key parameters of our model. They capture the complexity of the production process, the difficulty of the tasks involved in carrying out international commerce and the intricacies of the trading process. A high value for s_b indicates that workers gain basic experience quickly, suggesting that the production process is easy to grasp. Thus, more sophisticated and complicated production processes should be associated with lower values for s_b. There are two issues that are likely to influence the value of s_i. First, there is the difficulty of mastering the tasks needed to export a product. If these tasks are straightforward, workers should catch on quickly and s_i should be relatively large. For example, if the task is managing the supply chain, we would expect a high value of s_i if the supply chain is relatively short and easy to manage and a low value of s_i if the supply chain is more complex. Second, there is the nature of the trading relationship. For example, one could imagine that the supply chain would be more difficult to manage if the firm faced significant language barriers and/or geographical and cultural hurdles in order to do business in a specific country. In such a situation, we would expect s_i to be low.

In our model, experience does not depreciate in that once a worker acquires either form of experience, it remains with them throughout their life. Experience is not directly observable. To really know if a worker has the type of experience desired, a firm must screen. By construction, all workers with international experience also have basic experience, therefore firms screening for international experience

need not also screen for basic experience.

We argued above that active firms with the lowest productivity measures do not earn enough revenue to cover the cost of screening nor the cost of exporting, so they offer the low wage and serve only their home market. The new hires for these firms come entirely from new labor market entrants. As these workers age, some gain basic experience, and are poached by more productive firms. As a result, low-wage firms employ a mixture of inexperienced workers and workers with basic experience.

We also argued that the highest productivity firms face substantial export opportunities. This tips the balance in favor of poaching workers from lower-productivity exporting firms by offering a higher wage and paying to screen for international experience to ensure a workforce that minimizes trade costs.

The analysis of firms between these two extremes is more subtle. For all firms with intermediate productivity, the domestic market is sufficiently large to justify poaching workers from low-productivity, low-wage firms and screening for basic experience; but potential export opportunities are insufficient to justify the cost of screening for and paying a wage commensurate with international experience. Indeed, the fixed cost of exporting precludes firms at the low end of the middle range of productivities from entering foreign markets. In contrast, those at the upper end can export enough to overcome the fixed exporting cost. These two sets of firms pay wages w_n, and w_x, respectively.

Medium-productivity exporters offer workers a chance to gain international experience and provide a path to a higher wage at high-productivity exporters while non-exporters do not. Therefore, non-exporters pay a higher wage in order to induce workers to accept their offers. It follows that $w_n > w_x$.[8] With $w_n > w_x$ the relationship between wages and firm productivity is surprisingly non-monotonic. However, since low wage firms do not export and high-wage firms do, the *average* wage paid by exporters exceeds the *average* wage paid by non-exporters (consistent with the stylized facts on heterogeneous firms and trade).

[8] Depending on the parameters, it might be possible to have an equilibrium in which medium-productivity exporters poach from medium-wage non-exporters (rather than low-wage firms). This would allow the firm to avoid the fixed cost of screening but would require them to pay a higher wage (since it would be more difficult to induce such workers to move). However, in such an equilibrium all workers recruited by medium-wage exporters would be taking a pay cut when switching jobs. While some workers actually do take pay cuts to move, we would argue that an equilibrium in which all workers recruited by a particular class of firm take a pay cut to move is not empirically relevant.

Some of the workers employed by medium-productivity exporters eventually acquire international experience and are poached by high-productivity, high-wage exporters. Thus, medium-productivity exporters employ a mix of workers with basic experience and workers with international experience. This contrasts with the highest productivity firms that employ only fully experienced workers.

We conclude this subsection by emphasizing the fact that as productivity increases, firms take on more fixed costs, due to screening and exporting, in order to lower marginal costs (the increase in productivity outweighs the higher wages).

B. Labor Market Dynamics

We illustrate worker flows along the jobs ladder in Figure 2. Since δ_w is the death rate for workers, it is also the transition rate for workers into the labor force. In addition to the notation already described, L_{EF} denotes the number of workers with experience E employed at a type-F firm and L_J represents the total number of workers attached to the jobs ladder. Workers get the opportunity to move to a higher paying job if they have the appropriate experience and do so if the cost of moving is sufficiently low. To be precise, when given an opportunity to move, each worker randomly draws a cost κ and moves if the expected benefit from doing so exceeds this cost. Thus, moving costs are a random variable (κ) with cumulative distribution $G(\kappa)$ and density $g(\kappa)$.

Job offers arrive according to a Poisson process. We could use a_F to denote the arrival rate of opportunities to move to a type-F firm. However, for simplicity, we set all arrival rates equal to one.

The stationary equilibrium conditions related to the flows in Figure 2 are given in (1) below. In each case, the flow into the labor market state is on the left-hand-side while the flow out is on the right-hand-side. We start with (1.a), which applies to labor market state L_{0l} (inexperienced workers at low-wage firms). Since we only consider stationary equilibria, we hold constant the total measure of workers tied to the jobs ladder, L_J. The number of deaths $(\delta_w L_J)$ must be offset with an equal number of births, with each newborn taking a job at a low-wage firm. Thus, $\delta_w L_J$ is the flow into labor market state L_{0l}. As for the outflow, we know that every new entrant is inexperienced. Some inexperienced workers eventually obtain

basic experience (at rate s_b), while others die without ever having done so. Thus, the outflow of inexperienced workers is $(\delta_w + s_b)L_{0l}$.

(1.a) $\delta_w L_J = (\delta_w + s_b)L_{0l}$

(1.b) $s_b L_{ol} = \big(\delta_w + G(\kappa_n) + G(\kappa_x)\big)L_{bl}$

(1.c) $G(\kappa_n)L_{bl} = \delta_w L_{bn}$

(1.d) $G(\kappa_x)L_{bl} = (\delta_w + s_i)L_{bx}$

(1.e) $s_i L_{bx} = \big(\delta_w + G(\kappa_i)\big)L_{ix}$

(1.f) $G(\kappa_i)L_{ix} = \delta_w L_{ih}$

Turn next to (1.b), which equates the inflow and outflow from state L_{bl} (workers with basic experience at low-wage firms). The rate at which inexperienced workers gain basic experience is s_b, therefore the left-hand side of (1.b), which is the flow into state L_{bl}, is the measure of workers at low-wage firms that gain basic experience. Opportunities for low-wage experienced workers to move up the jobs ladder come from medium-productivity firms at rate one. We define κ_F as a critical moving cost such that workers drawing $\kappa \leq \kappa_F$ accept an offer from a type-F firm and move up the ladder. Therefore, $G(\kappa_F)$ represents the fraction of workers who accept an offer from a type-F firm. The right-hand side of (1.b) then represents the measure of experienced low-wage workers who transition out of that state due to death $(\delta_w L_{bl})$, acceptance of jobs at medium-productivity non-exporting firms $(G(\kappa_n)L_{bl})$, or acceptance of jobs at medium-productivity exporting firms $(G(\kappa_x)L_{bl})$. The remaining conditions are derived similarly.

C. Lifetime Real Income

Our forward looking workers make decisions in order to maximize expected lifetime real income. Let $V_{EF}(w_j)$ denote the expected lifetime real income for a worker with experience level E employed by a type-F firm earning wage w_j. In addition, we use ρ to denote the discount rate and $\tilde{p}$ to denote the price index (to be defined below). The right-hand side for each of the following value functions represents instantaneous income plus the expected capital gain (or minus the expected capital loss) from transitioning to a new labor-market state.

(2.a) $\rho V_{ol}(w_l) = \frac{w_l}{\tilde{p}} + s_b[V_{bl}(w_l) - V_{ol}(w_l)] - \delta_w V_{ol}(w_l)$

(2.b) $\rho V_{bl}(w_l) = \frac{w_l}{\tilde{p}} + G(\kappa_n)\big(V_{bn}(w_n) - V_{bl}(w_l) - E(\kappa|\kappa \leq \kappa_n)\big) +$

$$G(\kappa_x)\big(V_{bx}(w_x) - V_{bl}(w_l) - E(\kappa|\kappa \leq \kappa_x)\big) - \delta_w V_{bl}(w_l)$$

(2.c) $\rho V_{bn}(w_n) = \frac{w_n}{\tilde{p}} - \delta_w V_{bn}(w_n)$

(2.d) $\rho V_{bx}(w_x) = \frac{w_x}{\tilde{p}} + s_i\big(V_{ix}(w_x) - V_{bx}(w_x)\big) - \delta_w V_{bx}(w_x)$

(2.e) $\rho V_{ix}(w_x) = \frac{w_x}{\tilde{p}} + G(\kappa_i)\big(V_{ih}(w_h) - V_{ix}(w_x) - E(\kappa|\kappa \leq \kappa_i)\big) - \delta_w V_{ix}(w_x)$

(2.f) $\rho V_{ih}(w_h) = \frac{w_h}{\tilde{p}} - \delta_w V_{ih}(w_h)$

Starting with the first equation, the only possible transitions for an inexperienced worker are to either gain basic experience with a resulting capital gain $V_{bl}(w_l) - V_{ol}(w_l)$, or to exit the labor force and suffer a capital loss of $V_{ol}(w_l)$. These occur at rates s_b and δ_w, explaining (2.a).

A low-wage worker with basic experience has more possibilities. Such a worker might move to a medium-productivity non-exporter, earning a capital gain of $V_{bn}(w_n) - V_{bl}(w_l) - E(\kappa|\kappa \leq \kappa_n)$, or move to a medium-productivity exporter, earning a capital gain of $V_{bx}(w_x) - V_{bl}(w_l) - E(\kappa|\kappa \leq \kappa_x)$. In both cases, the capital gains account for expected moving costs. Of course, the worker could also exit the labor force and suffer a capital loss of $V_{bl}(w_l)$. These transitions occur at rates $G(\kappa_n)$, $G(\kappa_x)$, and δ_w, respectively. Derivation of the remaining asset-value equations follows the same logic.

As stated earlier the κ_F terms are defined such that a worker would accept an offer from a type-F firm if $\kappa \leq \kappa_F$. Formally, these critical values equal the difference between the value of climbing up one rung on the jobs ladder or remaining on the lower rung:[9]

(3.a) $\kappa_n = V_{bn}(w_n) - V_{bl}(w_l)$

[9] Note that even though $w_n > w_x$, in equilibrium it will be the case that $V_{bx} > V_{bn}$ – that is, entry level workers would prefer to move to a medium-wage exporter rather than a medium-wage non-exporter. This is because working for an exporter gives the worker access to higher paying jobs in the future. Workers receiving offers from medium-wage non-exporters are (in a sense) unlucky but accept the job anyway since the expected benefit of waiting for an offer from an exporter is below the cost of waiting.

(3.b) $\kappa_x = V_{bx}(w_x) - V_{bl}(w_l)$

(3.c) $\kappa_i = V_{ih}(w_h) - V_{ix}(w_x)$

We now turn to the entrepreneurship/jobs ladder decision confronting each newborn. We assume that each newborn is randomly endowed with some level of entrepreneurial talent, ε, with $H(\varepsilon)$ representing the cumulative distribution for this random variable. If we think of ε as efficiency units and use w_ε to denote the return to entrepreneurship per efficiency unit, then the flow income for an entrepreneur with ability ε is $\varepsilon w_\varepsilon$. It follows that the expected lifetime real income for an entrepreneur is

(2.g) $\rho V_\varepsilon(\varepsilon) = \frac{\varepsilon w_\varepsilon}{\tilde{p}} - \delta_w V_\varepsilon(\varepsilon)$

Newborns will choose to become an entrepreneur and spend their life developing new firms if $V_\varepsilon(\varepsilon)$ exceeds the return to entering the jobs ladder, $V_{0l}(w_l)$. Thus, if we let ε_0 denote the value that solves

(3.d) $V_\varepsilon(\varepsilon_0) = V_{0l}(w_l)$,

then all newborns with $\varepsilon \geq \varepsilon_0$ become entrepreneurs, while the remaining newborns enter the jobs ladder. If we use L to denote the total size of the labor force, it follows that

(4) $L_J = H(\varepsilon_0)L$

Conceptually, (2) and (3) provide the cutoff values for moving costs and entrepreneurial ability. These depend on endogenously determined wages along with the model's parameters. Substituting these cutoffs into equations (1) and (4) then generates the supplies of labor for all combinations of experience and firm-types. The next step is to derive the demands by each type of firm for each level of experience.

D. Prices and Output

We assume two identical countries populated by heterogeneous firms. Since the Foreign market is symmetric with Home, we focus on the Home country. As in Melitz (2003), prospective entrants incur a cost to draw a productivity parameter ϕ, a random variable with density $z(\phi)$ and cumulative distribution $Z(\phi)$. The firm's productivity combines with the experience of new hires to determine the productivity of labor. Specifically, we assume that the productivity of an inexperienced worker is zero, while the marginal productivity of a worker with basic experience is ϕ. We assume that basic experience reduces the cost of

production, while international experience lowers the cost of exporting. In particular, we assume iceberg transportation costs that are diminishing in the share of the firm's workforce with international experience.

We make the standard assumption that goods are horizontally differentiated and use $\sigma > 1$ to represent the constant elasticity of demand. Demand for a variety υ is given by

$$q(\upsilon) = \frac{R}{\tilde{p}^{1-\sigma}} p(\upsilon)^{-\sigma}$$

where R is total expenditure (and equal to firm revenue in equilibrium), $p(\upsilon)$ is the price of variety υ and $\tilde{p} \equiv [\int p(\upsilon)^{1-\sigma}\, d\upsilon]^{\frac{1}{1-\sigma}}$ is the price index.

Firms select into wage and export status based on productivity. Define $\phi_0 < \phi_l < \phi_n < \phi_x$ as a set of cutoff productivities. Firms with productivity below ϕ_0 cannot break even and do not produce. Firms with $\phi \in [\phi_0, \phi_l]$ forego screening and w_l. Firms with $\phi \in (\phi_l, \phi_n]$ screen for basic experience, pay w_n, and do not export. Firms with $\phi \in (\phi_n, \phi_x]$ screen for basic experience, pay w_x, and export. High productivity firms with $\phi > \phi_x$ screen for international experience, pay w_h, and export.

The prices that maximize profit are given in (5) below. All employees of medium-productivity and high-wage firms have marginal product of ϕ, meaning that the marginal costs for these firms are w/ϕ. Things are not as straight-forward for low-wage firms, where a fraction of their workers are inexperienced and have marginal productivity of zero, while the remaining workers are experienced with marginal productivity of ϕ. Therefore, the average product of labor for a low-wage firm is $(1 - \lambda_{0l})\phi$, where λ_{0l} is the fraction of the low-wage workforce that is inexperienced. We have:[10]

(5.a) $\quad p_l(\phi) = \frac{\sigma}{\sigma-1} \frac{w_l}{(1-\lambda_{0l})\phi}, \;\; \phi \in [\phi_0, \phi_l]$

(5.b) $\quad p_F(\phi) = \frac{\sigma}{\sigma-1} \frac{w_F}{\phi}$, with $F = n$ for $\phi \in (\phi_l, \phi_n]$; $F = x$ for $\phi \in (\phi_n, \phi_x]$; and $F = h$ for $\phi > \phi_x$

Things are a bit more complicated for the export market, because we want a firm's iceberg transportation

[10] In Melitz (2003) prices are a constant mark-up over marginal cost and workers are identical, so that marginal and average product are equal. In our model, the marginal worker hired by a low-wage firm is inexperienced and has a productivity of zero. This differs from average product, which is $(1 - \lambda_{0l})\phi$. In our dynamic model the firm's goal is to maximize its aggregate discounted stream of profits. With zero discounting (an assumption that we borrow from Melitz), this amounts to maximizing steady-state profits. For low-wage firms, this occurs when price is set as a mark-up over average product, as given in (5.a).

costs to depend on the fraction of its workforce with international experience. With this in mind, let λ_{EF} denote the fraction of workers with experience $E = o, b, i$ employed by a firm of type $F = l, n, x, h$. A type-F firm's cost of exporting is a function of λ_{iF}; in particular, we assume that a type-F firm must produce and ship $\frac{\tau q^*}{\lambda_{iF}}$ units of the product if it wishes to deliver q^* units to the foreign country. Note that we use τ to measure the degree of openness, with higher values of τ denoting freer (or less costly) trade. In equilibrium, all high-wage firms export and these firms only hire workers with international experience, so $\lambda_{ih} = 1$. Similarly, no employee of a non-exporter can gain international experience, implying that $\lambda_{il} = \lambda_{in} = 0$. Finally, for the medium-productivity exporters, a fraction of their workforce has international experience, so $0 < \lambda_{ix} \equiv \frac{L_{ix}}{L_{ix}+L_{bx}} < 1$. Therefore, prices for goods produced by Home firms for export are

(5.d) $p_x^*(\phi) = \frac{\sigma}{\sigma-1}\frac{w_m}{\phi}\frac{\tau}{\lambda_{ix}},\ \phi \in (\phi_n, \phi_x]$

(5.e) $p_h^*(\phi) = \frac{\sigma}{\sigma-1}\frac{\tau w_h}{\phi},\ \phi > \phi_x$

E. Labor Demand

Firms cannot costlessly identify experience among existing workers since experience acquisition is a Poisson process and identification requires costly screening. However, firms do know the average product of labor since they know the share of their workforce with experience and they know how productivity varies with experience. As described above, the average product of labor for a low-wage firm is $(1 - \lambda_{0l})\phi$, while the average product of labor for all other firms is ϕ. Therefore, the demand for labor needed to produce output for domestic sales is:

(6.a) $\ell_l(\phi) = f + \frac{q_l}{(1-\lambda_{ol})\phi}$

(6.b) $\ell_F(\phi) = f + f_b + \frac{q_F}{\phi}$ for $F = n, x$

(6.c) $\ell_h(\phi) = f + \frac{q_h}{\phi}$

where f is a fixed amount of labor needed for production, f_b is a fixed amount of labor needed to screen for basic experience and q_j follows from preferences in the obvious manner (note that we attribute the cost

of screening for international experience to the cost of exporting).

Similarly, we can write the amount of labor needed to produce output for export. For medium-productivity exporters and for high-wage firms, we have

(7.a) $\ell_x^*(\phi) = f_x + \frac{q_x^*}{\phi}\frac{\tau}{\lambda_{ix}}$

(7.b) $\ell_h^*(\phi) = f_x + f_i + \frac{\tau q_h^*}{\phi}$

The fixed cost of exporting is f_x, while the cost of screening for international experience is f_i in (7.b).

Let $\tilde{z}(\phi)$ represent the productivity distribution of firms conditional on successful entry. For now, take as given the critical productivity cutoffs that determine the of distribution firms. Then wages must adjust to equate the demand for each type of labor with the supply of that type. The demands by each firm F for workers with experience E are represented by (6.a) - (6.c) and (7.a) - (7.b). Integrating over the appropriate ranges of ϕ then yields total labor demand for each type. The supplies of each type of labor are given by the solutions to (1.a) - (1.f). Equating supply and demand for each type of labor gives us the equilibrium conditions in (8).

(8.a) $L_{ol} + L_{bl} = \mathcal{M}\int_{\phi_0}^{\phi_l} \ell_l(\phi)\tilde{z}(\phi)d\phi$

(8.b) $L_{bn} = \mathcal{M}\int_{\phi_l}^{\phi_n} \ell_n(\phi)\tilde{z}(\phi)d\phi$

(8.c) $L_{bx} + L_{ix} = \mathcal{M}\int_{\phi_n}^{\phi_x} [\ell_x(\phi) + \ell_x^*(\phi)]\tilde{z}(\phi)d\phi$

(8.d) $L_{ih} = \mathcal{M}\int_{\phi_x}^{\infty} [\ell_h(\phi) + \ell_h^*(\phi)]\tilde{z}(\phi)d\phi$

F. Firm Selection and Dynamics

Firms select their hiring and export strategies to maximize profit conditional on their productivity. Using $r_F(\phi)$ and $r_F^*(\phi)$ to represent revenue from domestic and export sales for a type-F firm, profits for the four types of firms are

(9.a) $\Pi_l(\phi) = \frac{r_l(\phi)}{\sigma} - w_l f$ for $\phi \in [\phi_0, \phi_l]$

(9.b) $\Pi_n(\phi) = \frac{r_n(\phi)}{\sigma} - w_n(f + f_b)$ for $\phi \in (\phi_l, \phi_n]$

(9.c) $\Pi_x(\phi) = \frac{r_x(\phi)+r_x^*(\phi)}{\sigma} - w_x[f + f_b + f_x]$ for $\phi \in (\phi_n, \phi_x]$

(9.d) $\Pi_h(\phi) = \frac{r_h(\phi)+r_h^*(\phi)}{\sigma} - w_h[f + f_i + f_x]$ for $\phi \geq \phi_x$

The critical productivity cutoffs satisfy the following equal profit conditions:

(10.a) $\Pi_l(\phi_0) = 0$

(10.b) $\Pi_l(\phi_l) = \Pi_n(\phi_l)$

(10.c) $\Pi_n(\phi_n) = \Pi_x(\phi_n)$

(10.d) $\Pi_x(\phi_x) = \Pi_h(\phi_x)$

Finally, we have a free entry condition stating that the sunk cost of developing a business plan must equal expected discounted profit. We assume that firms die (and are replaced) at rate δ_f. For tractability, we assume that each new entrant hires all the workers employed by the firm it replaces. If we assume that the development of a new firm requires f_d units of entrepreneurial inputs, then the sunk cost of development is $w_\varepsilon f_d$. Since the probability of successful entry is $1 - Z(\phi_0)$, the free entry condition is

(11) $\frac{1-Z(\phi_0)}{\rho+\delta_f}\int_{\phi_0}^{\infty} \Pi_F(\phi)\tilde{z}(\phi)d\phi = w_\varepsilon f_d$

If the discount rate is zero, all profit earned by the firm during its existence is paid to development labor (see Melitz 2003, footnote 16 for details). Combining this with wage income earned by production workers, we arrive at the final equation of the model, which equates aggregate labor income with aggregate revenue, R. Thus, in equilibrium we have

(12) $R = w_l(L_{ol} + L_{bl}) + w_n L_{bn} + w_x(L_{bx}+L_{ix}) + w_h L_{ih} + w_\varepsilon \bar{\varepsilon}(\varepsilon_0)(L - L_J)$

where $\bar{\varepsilon}(\varepsilon_0)$ is the mean of ε conditional on $\varepsilon \geq \varepsilon_0$ and $L_J = L_{ol} + L_{bl} + L_{bn} + L_{bx} + L_{ix} + L_{ih}$.

Equilibrium is characterized by the four job ladder wages (w_l, w_n, w_x, w_h), the return to entrepreneurship (w_ε), four critical productivities $(\phi_0, \phi_l, \phi_n, \phi_x)$, three critical moving costs $(\kappa_n, \kappa_x, \kappa_i)$, the critical level of entrepreneurial ability (ε_0), the mass of prospective firms (M_d), and national income (R). These fifteen variables are determined by five labor-market clearing conditions (4) and (8.a)–(8.d), four equal-profit conditions (10.a)–(10.d), four worker-indifference conditions (3.a)–(3.d), the free-entry

condition (11), and the national income identity (12).[11]

3. Globalization

A. Trade Costs and the Mix of Firm Types

We model globalization as a reduction in variable trade costs (an increase in τ), increasing the intensive margin of trade for those firms that already export while also changing the critical cutoff productivities that determine the mix of firm types. As we argue below, the number of high-wage exporting firms unambiguously increases as some medium-wage exporting firms find it more profitable to screen for experienced workers and pay the resulting higher wage. The number of medium-wage non-exporting firms unambiguously falls, with some now finding it more advantageous to export, while others drop into the low-wage category. The effects of globalization on the numbers low-wage firms and medium-wage exporters are ambiguous.

First, consider an exporter that is initially indifferent between screening for international experience and paying a high wage, or foregoing screening and paying a medium wage. Lower trade costs result in higher export intensity, thereby increasing the benefits of screening for internationally-skilled workers and paying the higher wage. The most productive medium-wage exporters become high-wage exporters, expanding the mass of high-wage firms, while reducing the mass of medium-wage exporting firms.

Next, consider a firm that is just indifferent between exporting and serving only the export market. Lower trade costs result in increased imports, making the domestic market more competitive. Expected profit from serving only the domestic market falls. A firm that also exports also earns less profit on domestic sales, but this is somewhat offset by increased export profit. Now the firm that was initially indifferent about exporting strictly prefers to export, decreasing the number of medium-wage non-exporters, while increasing the number of medium-wage exporters. Combined with the transition of some medium-wage exporters into high-wage status, the number of medium-wage exporters may rise or fall.

[11] The L_{EF} terms in (1) are also endogenous and appear in (8) and (12). However, there are six such terms and six equations in (1). These equations can be solved to obtain the L_{EF} terms as functions of our parameters and the cost cut-offs. In a similar vein, the equations in (2) can be solved allowing us to write the V_{EF} terms as functions of wages, cost cut-offs and ε_0. The resulting functions can then be substituted into (3), (8) and (12) to solve for equilibrium.

Finally, consider a firm that is initially indifferent between being a low-wage firm and a medium-wage non-exporter. Here it is helpful to realize that despite paying a higher wage, screening for basic experience reduces marginal cost and therefore results in a larger domestic market compared to the firm that does not screen. Therefore, medium-wage non-exporters have more to lose from import competition compared with a low-wage firm of similar productivity. The firm that is initially indifferent now strictly prefers to pay a lower wage. Combined with the result in the previous paragraph, medium-wage non-exporters are squeezed from both sides, as the most productive firms in that group become exporters; while the least productive members of the group stop screening and drop into the low-wage category.[12]

B. Calibration

To push our analysis further, we calibrate the model using many of the same parameters and targeting the same moments of the U.S. economy as in Melitz and Redding (2015). In what follows, we focus on how globalization affects the novel features of our model: the jobs ladder and economic mobility. Hence, we focus largely on production wages and transition rates. As discussed below, we find that our model yields robust predictions about the way in which lower trade costs impact the distribution of workers, firms, and income.

To begin, we assume that productivity, entrepreneurial ability and moving costs are drawn from independent Pareto distributions with all having minimum values of one. We set the shape parameter for the firm-productivity distribution equal to 4.25, so that we have the same degree of firm heterogeneity as Melitz and Redding (2015). Our numeric analysis indicates that while the spread of the moving cost distribution does plays a role in determining the amount of movement in the economy (and hence, overall

[12] This tends to increase the number of low-wage firms, but the effect could be offset by a higher productivity threshold for successful entry. The free entry condition requires that unconditional expected profit equals sunk costs. In the Meltiz model, sunk cost are parametrically determined, therefore the only margin of adjustment is that the likelihood of successful entry must fall (ϕ_0 increases) as ex-post expected profit increases, at least partially offsetting the increased number of low-wage firms resulting from the conversion of medium-wage non-exporters. But in our framework, sunk costs depend on the wage paid to development workers. This wage changes as trade costs fall, thereby changing sunk costs. If the return to entrepreneurship rises, the increase in sunk costs could outpace the increase in ex-post expected profit, making entry easier, reinforcing the increase in the number of low-wage firms.

economic mobility and the degree of responsiveness to changes in variable trade costs), it does not influence the qualitative properties of the model. We prove in Appendix A that any non-degenerate distribution of entrepreneurial ability with any parameterization results in qualitatively identical results since the distribution of ability only affects the split of work versus entrepreneurship, and the number of workers choosing the jobs ladder only affects the scale of economic activity.[13]

As for our parameters, we set $\delta_w = \frac{1}{40}$, so that workers have careers that last, on average, 40 years, and set $\delta_f = \frac{1}{18}$ so that the average life of a firm is 18 years.[14] For our base case, we set $s_b = \frac{1}{3}$ which implies that basic experience is picked up quickly (three years, on average), so that firms are willing to target low-wage workers that have only a few years of experience. We set the elasticity of substitution (σ) at 2.7, which is in the middle of the range reported by Borda and Weinstein (2006); and we take our initial value for trade costs (τ) from Anderson and van Wincoop (2004), setting $\tau = 1.7$.

Following Melitz and Redding, we require that in the initial equilibrium 18% of firms export; 14% of the revenue earned by exporting firms comes from their exports; and that the log difference between the revenue earned by exporters and the revenue earned by non-exporters is 1.48.[15] We add an additional target, requiring the success rate of new firms to be 80% (20% of all new firms fail within their first two years). For given values of the fixed costs of screening (f_b and f_i), these four targets allow us to pin down the remaining parameters of the model (f, f_x, f_d, and s_i). For our base case we set $f_b = f_i = 0.01$. Since $w_h > w_n > w_x$, this implies that the cost of screening for international experience exceeds the cost of screening for basic experience.

To ensure that our results are not sensitive to our parameter choices, we then carry-out sensitivity analysis with respect to our choices for s_b, f_b and f_i. Finally, as an additional check on the model, after

[13] In order to explore the quantitative effects of alternative assumptions, we re-calibrated the model assuming a uniform distribution of ability with $\varepsilon \in [0,1]$. The re-calibrated equilibrium was identical to the initial equilibrium (assuming the Pareto distribution) out to the third decimal place (or further) for all relevant variables.

[14] McKinsey reported that the average life of a firms in the S&P 500 in 2011 was 18 years. See also the 2017 report by Credit Suisse on Corporate Longevity which includes a survey of available evidence. This report is available at https://plus.credit-suisse.com/rpc4/ravDocView?docid=V6y0SB2AF-WEr1ce .

[15] Melitz and Redding take these targets from Bernard, Jensen, Redding and Schott (2007).

calibration is complete, we calculate the elasticity of trade and ensure the value predicted by our model falls within the range of estimates reported by Waugh and Simonovska (2014). For our base case, the elasticity of trade is 3.68, in the middle of the 2.79-4.46 range from Waugh and Simonovska.

C. Results

To explore the characteristics of our model, we vary τ from 1.45 to 1.90, with, as noted above, $\tau = 1.7$ serving as our base case. The lower bound for this range is taken from Anderson and van Wincoop (2004), who report estimates of trade costs for a variety of countries in their Table 6, with a low value near 1.45 (Belgium) and high values near 1.7 (US and Japan). The upper bound is set to include $\tau = 1.83$, which is the value Melitz and Redding (2015) use in their analysis.

Real wages for production workers are plotted against trade costs for our base case in Figure 3.[16] As the figure indicates, in the neighborhood of the initial equilibrium ($\tau = 1.7$) and for most of the parameter space, globalization results in real wage gains for those earning the two highest wages (w_h and w_n) and a reduction in the real wage earned by those in entry-level jobs. The sharpest gains go to high-wage workers. Thus, globalization increases inequality and can harm the lowest-paid production workers in the economy.

Since unskilled labor is the numeraire, the real-wage paid by low-wage firms is simply the inverse of the price index. A reduction in trade costs necessarily reduces the price index and raises the real wage for all workers in a plain-vanilla Melitz model. That is not the case in our model. Lower trade costs shuffle the mix of firms resulting in a number of offsetting effects. For example, the highest productivity medium-wage firms switch to become high-wage firms when trade costs fall. This increases their marginal cost of serving the domestic market, thereby increasing the price of their output. In addition, the lower-productivity medium-wage firms become low-wage firms in order to eliminate the fixed cost of screening. The lower wage, however, is more than offset by lower worker productivity.[17] Therefore the marginal cost of production increases for this group of firms as well. These two effects can offset the lower cost of imports

[16] Because of scale differences, we illustrate the three highest wages in the first panel of Figure 3 and the lowest wage in the second panel of the figure.

[17] Recall that the difference between medium-wage and high-wage workers lies in their differential ability to reduce trade costs, with both groups equally productive in serving the domestic market.

when the volume of imports is relatively small but are eventually dominated by lower import prices when trade costs fall far enough. Therefore low-income workers are harmed as trade costs fall over most of parameter space but start to see their real wages rise as τ approaches our lower bound (1.45). This non-monotonicity in the real income of low-wage workers is a general feature of the model, arising in all cases that we considered, with the increase always occurring for a value of τ below 1.7.

Turn next to Figure 4, where we report the share of each worker type relative to all production workers. Increased globalization has a small impact on low-wage jobs as a share of all production jobs. While the lowest productivity firms usually exit the market as trade costs fall, the lowest productivity non-exporting firms replace them. The former can be smaller or larger than the latter. As a result, low-wage employment as a share of production employment can rise or fall. In our base case, entry–level employment is non-monotonic in trade costs, dropping from 8.46% to (roughly) 8.13% and then rising back to 8.15%.

The reduction in trade costs results in more exports (intensive margin) and more exporters (extensive margin). The combined effect is to increase the share of high-wage jobs; rising from about 20% of production employment when τ is 1.83 to over 28% when τ drops to 1.4. Combined with the very small change in the share of low-wage jobs, the share of medium-wage jobs must fall.

Figure 4 also shows the breakdown of the two types of middle-wage jobs. As is evident, the reduction in the share of these jobs results from a precipitous fall in workers employed by non-exporting firms. Specifically, employment at medium-productivity non-exporters falls from about 60% of all production jobs to 44% over the range of trade costs that we consider. In the example depicted in Figure 4, employment at medium-productivity exporters grows from just under 13% to over 19%. This increase in the availability of jobs with medium-productivity exporters is important, since it makes it easier for workers to gain international experience and climb to the top of the jobs ladder.

To summarize, we find that lower trade costs are usually associated with increased wage inequality among production workers and that the share of production workers in medium-wage jobs shrinks as employment moves towards high-wage firms. As emphasized in the introduction, these predictions are broadly consistent with what we would see in most heterogeneous-firm trade models in which firms hire

from the same pool of workers (e.g., Egger and Kreickemeir 2012, Helpman, et al 2010a,b or Sampson 2014) and with recent empirical findings (Helpman, et al 2017). However, as stressed in the introduction, for workers that have careers in which they change jobs overtime, information about wage inequality and employment shares is not sufficient to fully address the link between globalization and inequality.

We now turn to the issue of economic mobility. In our model, low-wage workers see their relative wages fall with globalization. However, workers take low-wage jobs in order to acquire skills and hope to move on to higher paying jobs as quickly as possible. Thus, their welfare depends on all wages they earn over their lifetimes and the rates at which they move from job to job. If globalization reduces the average time spent in low-wage and medium-wage jobs, current low-wage workers might not care that much even if the reduction in trade costs lowers their real wage, since they know that better prospects lie ahead and that they will get to these better prospects more quickly. To investigate this issue, we calculate the expected duration in low-wage jobs and the expected duration of a job with a medium-productivity exporter. In both cases, we are interested in the expected duration conditional on the worker having already gained the skills necessary to move to the next rung of the ladder (since this is the only part of job duration that varies with behavior in our model). These measures, denoted by D_{bl} and D_{ix}, respectively, are given in (13) below.

$$(13) \qquad D_{bl} = \frac{1}{\delta_w + G(\kappa_n) + G(\kappa_x)} \quad \text{and} \quad D_{ix} = \frac{1}{\delta_w + G(\kappa_i)}$$

In each case, expected duration is the inverse of the overall transition rate out of that particular labor market state (see section 2.B above for a discussion of these transition rates).

The impact of globalization on the duration of medium-wage jobs with exporters is straightforward. Since globalization increases the gap between w_x and w_h, workers are more anxious to accept high wage offers. Thus, globalization increases the critical cost cut-off for workers employed in medium-productivity exporting jobs (κ_i), thereby increasing $G(\kappa_i)$ and reducing D_{ix}.

The impact of globalization on the duration of low-wage jobs is more complicated. There are two effects that work in opposite directions. With high-wage jobs becoming more valuable, low-wage workers become more willing to accept jobs from medium-productivity exporters, but less willing to accept the

dead-end jobs offered by medium-productivity non-exporters. Thus, $G(\kappa_x)$ rises while $G(\kappa_n)$ falls, making the overall impact on D_{bl} ambiguous. In our base case, the impact of globalization on the expected duration of a low-wage job is non-monotonic, falling as trade costs fall for most of the parameter space, turning up only as τ approaches our lower bound (see Figure 5). This u-shaped pattern appears to be quite general, with the only difference in the examples that we have examined being the point at which D_{bl} is minimized.

Our results indicate that globalization tends to produce two *countervailing* forces that affect the welfare of low-wage workers. On the one hand, their relative standing in the labor market is eroded, as wage inequality increases. On the other hand, globalization allows them to move up the jobs ladder more quickly and, as they reach higher rungs, they enjoy the enhanced benefits of the higher real wages generated by freer trade. In this case, a focus on wage inequality can be misleading in that low-wage workers do not lose as much relative to others in the labor market as would be indicated by standard analysis.

In this framework, the proper way to measure the effect of globalization on a worker is to examine its impact on that worker's expected lifetime real income. That measure considers both the change in real wages and the degree of economic mobility faced by that worker. Thus, we can get a better view of how globalization affects inequality by examining the changes in expected lifetime real incomes for workers in different labor market states. There are many ways to measure inequality, especially in a framework such as this one which includes many labor markets states. For simplicity, we focus on the impact of globalization on the relative standing of the workers at the bottom and the top of the jobs ladder. For our measure of wage inequality, we investigate how globalization impacts the ratio of the wages paid to highest-paid workers to those earning the lowest wage; that is, $\frac{w_h}{w_l}$. Based on our calibration, this value is 2.08 for our highest trade cost, rising to 2.47 as trade costs fall to our lowest value, an increase of 18.8%.

Turn next to expected lifetime real income. Our measure on inequality in this dimension is $\frac{V_{ih}}{V_{ol}}$. The numerator is the expected lifetime real income for a worker that has international experience and has managed to secure a job at a high-wage exporter. The denominator is the expected lifetime real income of a newborn worker – a worker with no experience employed by a low-wage firm. This ratio, as a function

of trade costs, is shown in Figure 6 for our base case example, along with the ratio of wages. There are several features of Figure 6 that are worth emphasizing. First, this ratio is 1.09 for the highest level of trade costs that we consider. That this measure is lower than the ratio of wages shows how misleading it can be to focus on wages and ignore economic mobility. Inexperienced workers only hold low-wage jobs for a small portion of their lifetime, moving on to better jobs as they gain skills. As they mature, they benefit from the higher real wages paid to medium-wage and high-wage production workers if they can gain the proper skills and land better jobs. The fact that using current wages as a proxy for lifetime earnings can lead to misleading conclusions is not a new insight. This issue is well understood and heavily researched in many sub-fields of economics; but, as far as we know, it has not received much attention from those investigating the link between globalization and inequality.[18]

The second feature in Figure 6 worth noting is that, in our example, $\frac{V_{ih}}{V_{ol}}$ rises much more modestly than our measure of wage inequality. The overstatement of inequality based on looking only at current wages becomes more severe as trade costs fall. The third point to make about Figure 6 is that the positive relationship between $\frac{V_{ih}}{V_{ol}}$ and trade costs depicted in Figure 6 is *not* a general result – in some examples, this value actually *falls* as trade costs approach our lower bound.

D. Sensitivity Analysis

We close this section by describing the sensitivity analysis that we carried out to check on the robustness of our results. There are three dimensions that we focused on: our parameter choices; assumptions made about the distributions of random variables; and the overall structure of the model.

We begin with our assumptions about two distributions, those describing entrepreneurial ability and moving costs. As we noted above, equilibrium on the jobs ladder is independent of the parameters that characterize the distribution of entrepreneurial ability. To understand this, consider the two conditions that determine the equilibrium for entrepreneurial labor. First, expected lifetime income for the marginal

[18] In labor economics, a classic reference is Lillard (1977). Haider and Solon (2006) discuss the determinants that make current earnings either a good or bad proxy for lifetime earnings. For an example of the importance of this distinction in calculating tax incidence see Davies, St-Hilaire and Whalley (1984) or Fullerton and Rogers (1993).

entrepreneur $\left(\frac{w_\varepsilon \varepsilon_0}{\rho+\delta_w}\right)$ must equal the expected lifetime income for an inexperienced low-wage worker. Second, aggregate entrepreneurial income ($w_\varepsilon L_\varepsilon$) must equal aggregate profit. Expected lifetime income and aggregate profit are both unchanged if there is no disturbance to the jobs ladder. Given the distribution of entrepreneurial ability, L_ε is a function of ε_0. Therefore, these two conditions fully determine w_ε and ε_0. Any change in the distribution of entrepreneurial ability (including any distribution function other than Pareto) only affects the equilibrium marginal ability and the wage per unit of entrepreneurial skill.

As for moving costs, we vary the shape parameter of the Pareto distribution from a very low value, so that moving costs are quite spread out, to a very high value, so that moving costs are quite concentrated. For low values, economic mobility is low, with workers accepting (on average) about 10% of the offers they receive; while for high values, economic mobility is much higher, with workers accepting (on average) about 98% of their offers. In turn, more mobility results in higher trade elasticity in the neighborhood of the initial equilibrium. However, in all cases, the qualitative impact of globalization is consistent with our base case, indicating that our results do not hinge on choices that we make with respect to moving costs.

Turn next to our parameter choices. In our sensitivity analysis we focus on three key values: the elasticity of substitution (σ), the transition rate for workers gaining basic experience (s_b) and the relative values of the cost of screening for basic and international experience (f_b and f_i). Our values for σ come from Broda and Weinstein (2006), who report estimates ranging from 2.2 to 3.1 with a median of 2.7 (see their Table 4). While we used 2.7 as our base case, we also carried out our analysis for the two extreme values, 2.2 and 3.1. In Table 1 we report our results for all three cases, with the trade elasticity for the case in which $\tau = 1.7$ listed below the value for σ. The entries in the table are elasticities with respect to trade costs. As trade costs fall, one would expect real wages to rise and job durations to fall, so wage elasticities should generally be negative and the elasticities for job durations should be positive. The results in Table 1 show that the properties of the model displayed in Figures 3 and 5 are robust. In all cases, as trade costs fall, the two highest real wages increase and the real wage earned by entry-level workers is u-shaped, falling at first and then eventually rising. The entries also reveal that the second-lowest wage in the economy, that

earned by workers at medium-productivity exporters is also non-monotonic in trade cost, following a pattern similar to that of the low wage. However, workers earning w_x start to enjoy real wage gains much sooner than low wage workers, with their gains always kicking in around $\tau = 1.7$, while entry-level workers do not gain in real terms until τ drops to 1.54 (when σ = 2.7 or 3.1). One new feature revealed by Table 1 is that in some very rare cases a reduction in trade costs can cause inequality to actually fall, with entry-level workers gaining the most from globalization. This never happens when $\sigma = 2.7$, it happens only as τ approaches our lower bound when $\sigma = 3.1$, and it happens when τ falls below 1.55 when $\sigma = 2.2$. The dramatic increase in the real income for low wage workers when trade costs are low is driven by the difficulty that entry-level firms face in retaining workers as exporting firms expand.[19] Finally, the impact of globalization on job durations is completely consistent with our base case – as trade costs fall, the duration of medium-wage jobs always drops (although the effect is quite small for low σ), while the impact on the duration of low-wage jobs is u-shaped with duration eventually rising for very low trade costs. As for the remaining parameters, we carried out our analysis varying s_b from .25 to .5 and $\frac{f_i}{f_b}$ from 1 to 2 and found no noteworthy change in the comparative statics predictions of the model.

Finally, we turn to the structure of our model. Two of our key assumptions are that workers make their entrepreneurial/jobs ladder decision at birth, and that medium-productivity exporters and non-exporters pay different wages. In an earlier version of this paper, we made different choices. In particular, we assumed that workers needed to gain both basic and international experience before starting to develop new firms, so that entrepreneurs held jobs at the very top of the jobs ladder, and we restricted all medium-productivity firms to pay the same wage regardless of exporting status. This model yields comparative statics predictions that are almost identical to those reported above (see Davidson el at 2018 for details).

[19] Helpman, et al (2010a) also find that inequality is non-monotonic in trade costs but for different reasons. In their model, as the economy moves away from autarky, inequality rises as the most productive firms start to export – thus, globalization magnifies firm heterogeneity as only the most productive firms are able to access world markets. As trade costs continue to fall, more firms export; and, eventually they fall to the level at which *all* firms export. At that point, inequality *is decreasing in trade costs* since as the weakest firms begin to export, firm heterogeneity falls. This effect does not arise in our model since we only consider equilibria in which some firms do not export.

There are only two differences. In Davidson el at (2018) employment at low-wage firms always rises (but very modestly) as trade costs fall and in our base case our measure of inequality that relies on expected lifetime earnings *falls* by 15% as trade costs drop. As a further check for robustness, we took the model with entrepreneurs at the top of the jobs ladder and relaxed the assumption that all medium-productivity firms must offer the same wage. Relaxing this assumption did not overturn a single result reported above.

4. Discussion

Our model yields a variety of testable predictions about the impact of globalization on the career-paths of workers. While a detailed empirical analysis is beyond the scope of this paper, we feel that it is important to discuss how our results should be interpreted, since our preferred interpretation has clear implications for the manner in which we believe these predictions should be tested.

In our model, firms employ workers to perform two tasks – production of output and, if the firm is an exporter, shipment of goods abroad. The firm's ability to produce output depends on how much basic experience is embedded in its workforce; while its trade costs depend on the faction of its workforce with international experience. In addition, the economy-wide wage distribution applies to all workers, regardless of experience. In reality, firms are far more complex than this, requiring a large number of tasks to be carried out both for production and distribution. Firms employ workers in a wide variety of occupations to carry out these tasks and the wage distributions for different occupations are largely distinct. Thus, the most appropriate way to view our model is that it describes a jobs ladder for workers in a particular occupation. Further, it is easy to imagine that international experience plays a larger role in lowering trade costs in some occupations (e.g., supply chain or business development managers, business tax or global trade lawyers, experts in international finance) relative to others (e.g., clerical support). That is, we expect that our predictions are more likely to find support in occupations that play a major role in international commerce, such as professionals and managers. Indeed, in Davidson et al (2019), we carry out an occupation-specific analysis of globalization and economic mobility and find results that are in line with our predictions for managers and professionals, while no clear link emerges for clerks.

We close this section by describing two potentially important extensions of our model and the

manner in which we expect our results to be affected. The first extension has to do with downward mobility while the second allows workers to gain skills via education. As constructed, each worker in this economy follows a similar path up to the top of the jobs ladder; but, there are no moves back down the ladder. However, in reality, some workers are demoted by their employer and others are let go and forced to accept a new, lower wage to gain reemployment. Using US data covering 1994 to 2016 Forsythe (2017) finds that "approximately 7% of employed individuals move down the occupational ladder each year." Accordingly, using Danish data, Groes, Kirchner and Manovskii (2013) and Frederiksen, Halliday and Koch (2016) find substantial rates of downward economic mobility. Such movements back down the ladder can be devastating for individual workers, resulting in large losses in lifetime earnings.[20] These downward movements can also retard the development of an effective career.

To allow for downward economic mobility, we could assume that once a worker gains a skill and uses it to secure a better job, they must then exert effort to keep that skill from deteriorating. Effort would be costly, with the cost varying across workers. The cost of effort could be modeled in the same manner as moving costs – once a skill is gained and a better job is secured, the worker would get a random draw that determines the cost of effort. Skills would not deteriorate if the worker exerts effort, but would disappear with a reversion to the previous productivity level if the worker does not. To prevent shirking, firms would monitor workers and fire those that have lost their skills. Thus, shirking workers would risk detection with the prospect of falling back one level on the ladder where they would have to re-acquire that skill if they wanted to move back up and earn a higher wage. In this setting, workers would make the choice between effort and shirking by comparing the cost of effort with the expected loss from shirking. We believe that such an extension would yield a new insight – since globalization increases wage inequality, it increases the expected loss in earnings associated with shirking. As a result, fewer workers would shirk as trade costs fall and there would be fewer demotions. Such a result would have implications for expected job duration. Since fewer medium-wage workers would be demoted, the fraction of a worker's lifetime

[20] The classic references on the losses from job displacement are Jacobson, LaLonde and Sullivan (1993) and Kletzer (1998). For more recent discussion, see Davis and von Wachter (2011) or Krolikowski (2017).

spent in entry-level jobs would decrease. And, since fewer high-wage workers would shirk, the fraction of a worker's lifetime spent at the top of the jobs ladder increases. As for medium-wage workers, the impact of globalization on job duration would become uncertain. On the one hand, the forces uncovered in section 3 imply that as trade costs fall, a worker at a medium-wage firm will move up and accept a higher paying job more rapidly. On the other hand, since globalization would reduce the number of medium-wage workers that shirk, these workers would be less likely to be fired and forced to take lower paying jobs. The former effect reduces the expected duration of a medium-wage job while the latter effect increases it.

The second extension has to do with the manner in which workers gain their skills. In our current model, this is accomplished on the job. While on-the-job training is an important component of real world labor markets, it is also true that many workers circumvent the lower rungs of the jobs ladder by acquiring skills through schooling. Thus, we could extend the model to allow workers to choose between gaining skills on the job or via education. It would be natural to assume that the education process is costly and time consuming, requiring those who choose this path to forgo earnings while in school. Workers would differ in ability, which would translate into different costs of schooling. In equilibrium, highly able individuals, with low education costs, would enroll in school, while less able individuals would join the labor force as soon as they are born. Since education allows workers to skip rungs on the jobs ladder, we expect the effects of globalization to be magnified.[21] This main reason for this is that if workers can gain international experience without working at a medium-wage exporter, the shrinking of the measure of medium wage firms that results from lower trade costs will no longer be constrained by the need to train workers for high-paying jobs at internationally engaged firms. Employment will still shift from non-exporters to exporters, but the reduction in medium-wage employment should be more dramatic, leading to an increase in employment in *all* other categories *including* low-wage employment. The end result would be that when workers can acquire skills through education, globalization can lead to a hollowing out of the

[21] This result is present in our earlier working paper (Davidson, Heyman, Matusz, Sjoholm and Zhu 2017) that included education as a method for gaining skills. We are currently working on a revised version of that model that offers a richer framework for examining the interactions between globalization, educational choice and economic mobility.

wage distribution within an industry. As trade costs fall, more workers would choose the schooling option and wind up in high-paying jobs, with those electing to acquire their skills on the job spending more time earning the low wage – that is, globalization would lead to more firms offering the extreme wages in the wage distribution, with fewer offering the medium wage.[22]

5. Conclusion

Most workers land their first full-time job in their 20s and then spend 40 to 50 years in the labor market trying to earn a living. Over their careers, workers acquire new skills, which enables them to change jobs and (sometimes) occupations in order to increase job satisfaction and career earnings. It follows that a complete picture of the impact of globalization on a typical worker should take into account its impact on skill acquisition and the rate at which workers are able to secure better jobs (that is, economic mobility).

In this paper, we have provided a framework to investigate such issues. In particular, we have developed a model of a jobs ladder in which workers gain skills on the job that qualify them for higher-paying jobs at more productive firms. Productivity is not directly observable, requiring firms to screen workers during the recruiting process. Firms then self-select into different groups based on the wages that they pay, their level of international engagement, the type of screening that they use and networks that they use to recruit workers. Low-productivity firms pay low wages and recruit only inexperienced workers. These firms do not earn enough revenue to cover the cost of accessing world markets, and thus, sell their output domestically. Medium-productivity firms pay higher wages, recruit workers away from low-wage firms and screen them to ensure that they have acquired skills that reduce the marginal cost of production. High-productivity medium-wage firms export a portion of their output, while low-productivity medium-wage firms do not engage in international markets. Finally, high-productivity firms pay high-wages, export a fraction of their output, and poach workers from medium-wage exporters. These firms screen for the type of skills that reduce the cost of exporting. Globalization alters the mix of jobs available and thus changes

[22] For evidence that workers alter their schooling decisions based on changes in trade flows see Atkin (2016) and Blanchard and Olney (2017).

the rate at which workers gain skills and move up the jobs ladder.

Our main finding is that globalization increases economic mobility through two channels. First, the reduction in trade costs leads to more international engagement by firms. As the number of exporting firms grows, the ability of workers to gain skills that reduce trade costs is enhanced. This makes it easier for workers to qualify for jobs at the top of the jobs ladder. Second, since high-productivity firms gain disproportionally from falling trade costs, globalization increases wage inequality. And, as the gaps between the wages paid by different groups of firms increase, workers become more willing to incur the moving costs associated with changing jobs. As a result, economic mobility rises. This change in economic mobility reduces the differences in expected lifetime incomes forecast by workers in high-wage and low-wage jobs, resulting in the possibility that inequality in lifetime incomes might fall with globalization (even though wage inequality is rising). Even the case in which globalization increases inequality in terms of lifetime incomes, the impact is smaller than its impact on wage inequality. Thus, our model yields several potentially important predictions that deserve detailed empirical scrutiny.

Finally, we note that recent empirical work has found shrinking employment in middle-wage occupations in favor of employment gains in both low-wage and high-wage occupations (see Goos and Manning 2007; Goos, Manning, and Salomons 2009; Autor, Katz and Kearney 2006, 2008 and Autor and Dorn 2013). This job polarization has been largely linked with offshoring. Complementary with this work, our results indicate that globalization can result in a shrinking middle-class *even within a given occupation and even without offshoring*. In particular, the labor market in our model consists of workers in a single occupation and we model globalization as a reduction in trade costs. In this context, we show that globalization alters the networks that firms use to fill their vacancies and that this reduces the number of jobs that pay midlevel wages. This is because expanded export opportunities increase the incentives for the strongest firms to recruit the most experienced workers by paying the high wages; while more intense import competition causes weak firms to re-orient their hiring toward inexperienced low-wage workers.

Appendix

The distribution of entrepreneurial ability has no effect on the equilibrium jobs ladder. In any equilibrium, expected lifetime utility for an entrepreneur must equal expected lifetime income for an inexperienced worker (from eq. 3.d in the text):

$$(A.1) \quad V_\varepsilon(\varepsilon_0) = V_{0l}(w_l)$$

It must also be true that total entrepreneurial income absorbs all expected profit (from eq. 11 in the text, slightly re-written):

$$(A.2) \quad w_\varepsilon \, \bar{\varepsilon}(\varepsilon_0) L_\varepsilon(\varepsilon_0) = \frac{1-Z(\phi_0)}{\rho+\delta_f} \mathcal{M} \int_{\phi_0}^{\infty} \Pi_F(\phi) \tilde{z}(\phi) d\phi$$

where, as in the text, $\bar{\varepsilon}(\varepsilon_0)$ is the mean of ε conditional on $\varepsilon \geq \varepsilon_0$. Since $H(\varepsilon)$ represents the distribution function of entrepreneurial ability, $L_\varepsilon(\varepsilon_0) = \big(1 - H(\varepsilon_0)\big)L$, and $\bar{\varepsilon}(\varepsilon_0) = \int_{\varepsilon_0}^{\infty} \varepsilon \tilde{h}(\varepsilon) d\varepsilon$ so we can re-write $(A.2)$

$$(A.3) \qquad w_\varepsilon \int_{\varepsilon_0}^{\infty} \varepsilon \tilde{h}(\varepsilon) d\varepsilon \, \big(1 - H(\varepsilon_0)\big) L = \frac{1-Z(\phi_0)}{\rho+\delta_f} \mathcal{M} \int_{\phi_0}^{\infty} \Pi_F(\phi) \tilde{z}(\phi) d\phi$$

Given all of the equilibrium values of the variables along the jobs ladder, equations $(A.1)$ and $(A.3)$ determine the equilibrium values of w_ε and ε_0. Any change in the distribution of entrepreneurial ability is reflected in a change in these two equilibrium values, which in turn affect only the distribution of workers between entrepreneurship and production. Changes in the mass of production workers affects only the scale of economic activity without any impact on the qualitative properties of the jobs ladder.

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Figure 1: The Firm's Decision Tree

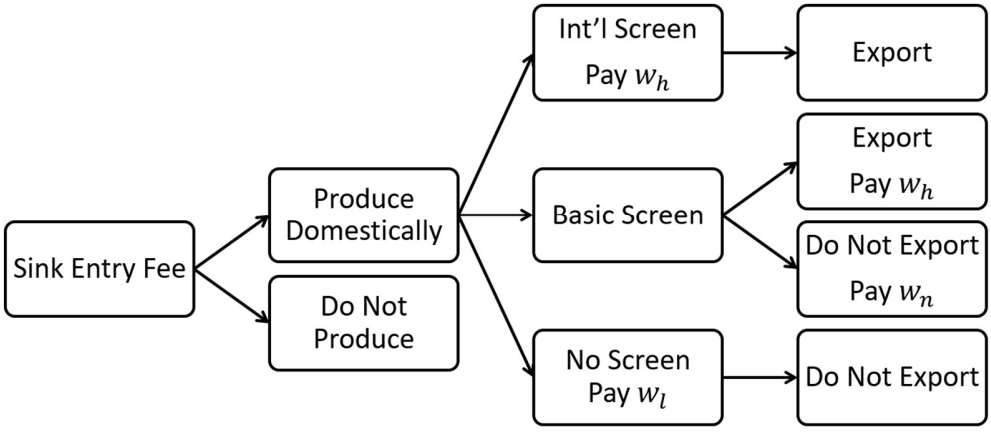


Figure 2: Worker Flows

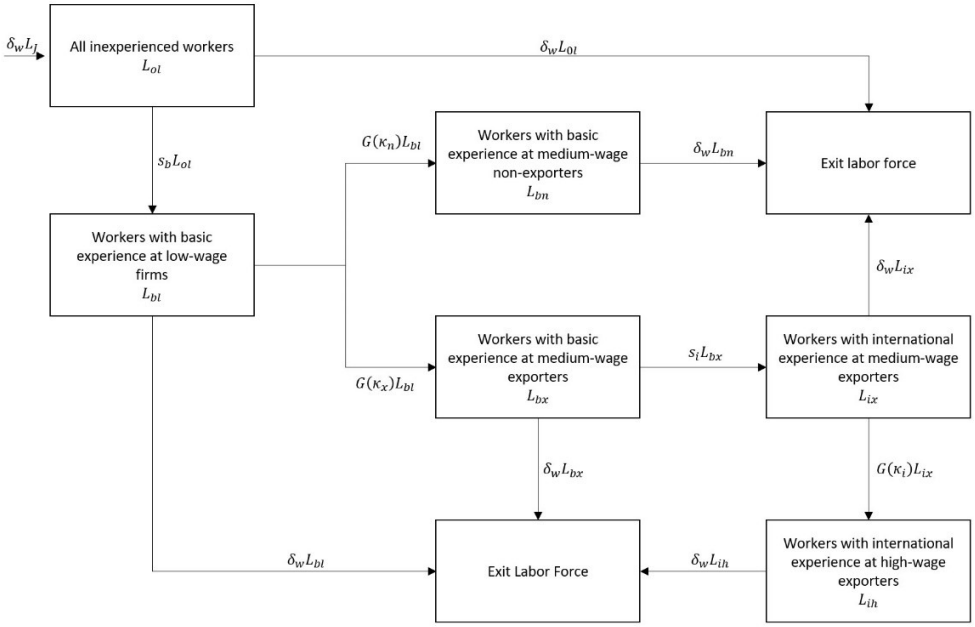
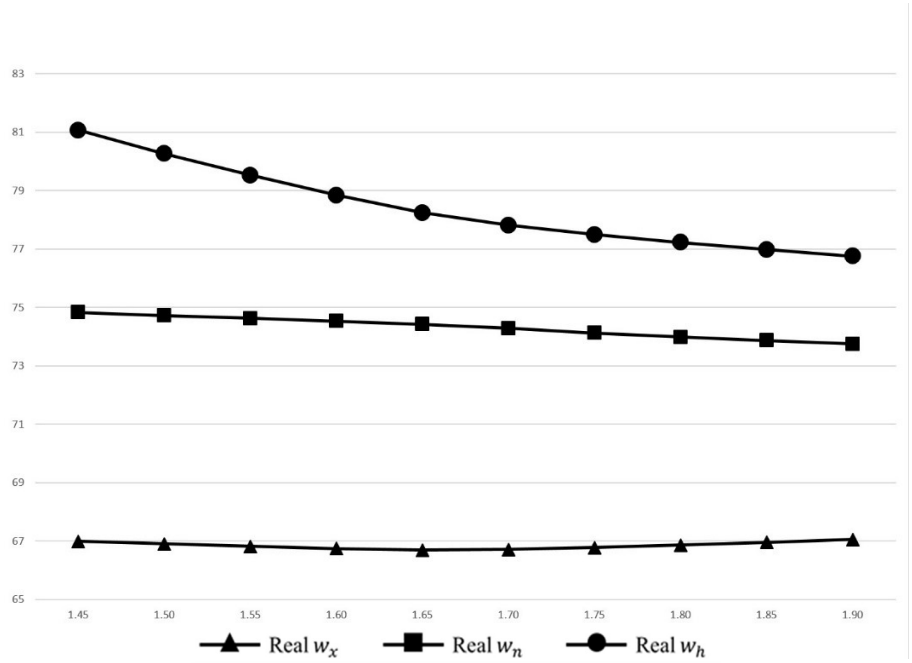


Figure 3: Real Wage Effects



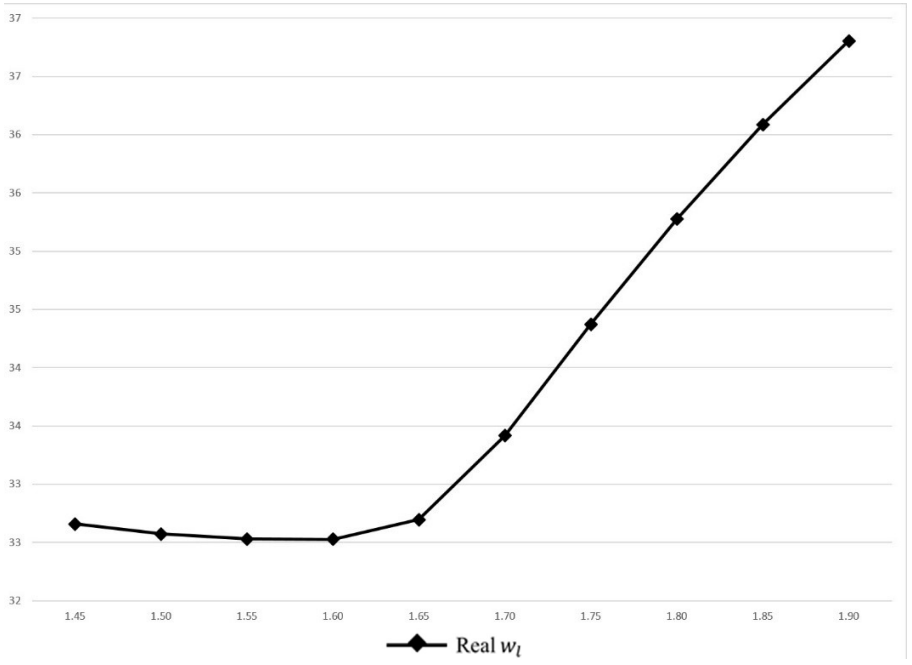


Figure 4: Employment Shares by Firm Type

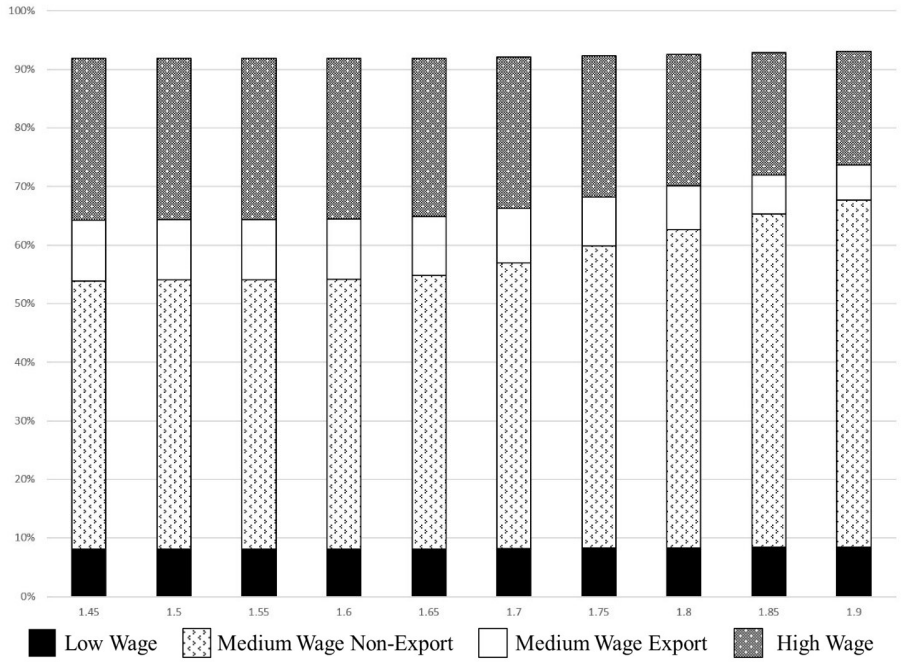


Figure 5: Average Duration of Low-Wage Jobs

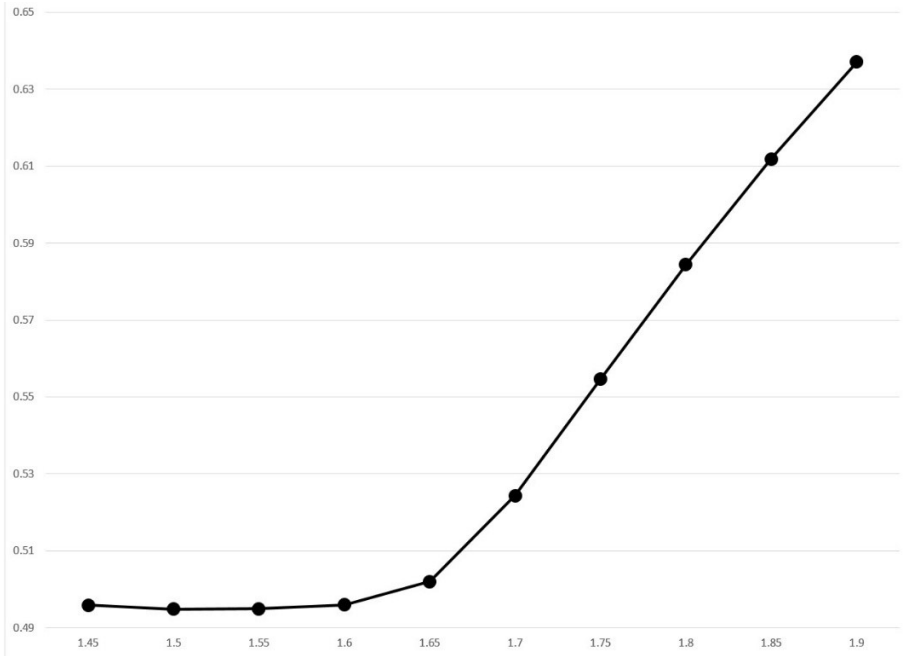


Figure 6: Measures of Inequality

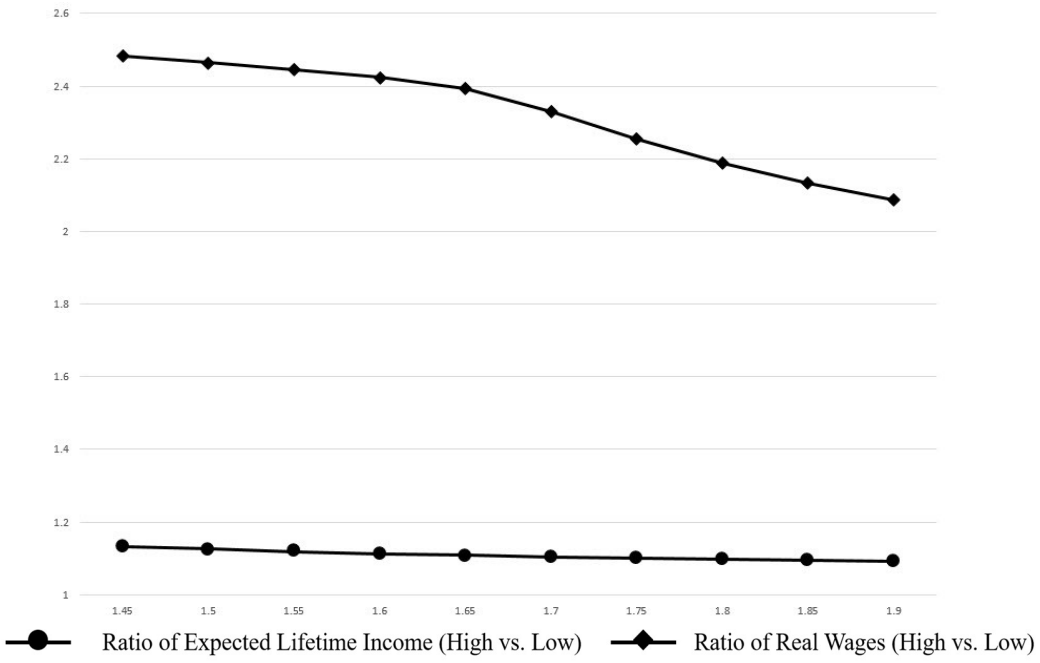


Table 1A: Sensitivity Analysis

$\sigma = 2.7$

(Trade Elasticity = 3.68)

	τ	**1.45**	**1.50**	**1.55**	**1.60**	**1.65**	**1.70**	**1.75**	**1.80**	**1.85**	**1.90**
Real Wage Elasticities	w_l	-.125	-.051	-.026	.037	.420	.948	.962	.874	.781	.698
	w_x	-.041	-.040	-.037	-.033	-.011	.027	.041	.048	.053	.057
	w_n	-.048	-.042	-.040	-.040	-.054	-.072	-.070	-.064	-.058	-.052
	w_h	-.296	-.289	-.278	-.263	-.219	-.155	-.131	-.120	-.111	-.104
Duration Elasticities	D_{bl}	-.145	-.017	.026	.143	.871	1.89	1.92	1.76	1.59	1.43
	D_{ix}	.011	.012	.013	.014	.014	.013	.013	.014	.015	.016

Table 1B: Sensitivity Analysis

$\sigma = 3.1$

(Trade Elasticity = 3.01)

	τ	**1.45**	**1.50**	**1.55**	**1.60**	**1.65**	**1.70**	**1.75**	**1.80**	**1.85**	**1.90**
Real Wage Elasticities	w_l	-.391	-.224	-.089	.023	.115	.192	.225	.304	.342	.368
	w_x	-.023	-.018	-.014	-.009	-.005	.000	.005	.010	.015	.019
	w_n	-.089	-.077	-.069	-.063	-.059	-.056	-.054	-.051	-.049	-.047
	w_h	-.250	-.239	-.227	-.214	-.201	-.188	-.175	-.162	-.150	-.139
Duration Elasticities	D_{bl}	-.551	-.271	-.041	.150	.310	.443	.552	.640	.706	.753
	D_{ix}	.600	.625	.647	.667	.685	.702	.718	.734	.749	.765

Table 1C: Sensitivity Analysis

$\sigma = 2.2$

(Trade Elasticity = 4.54)

	τ	**1.45**	**1.50**	**1.55**	**1.60**	**1.65**	**1.70**	**1.75**	**1.80**	**1.85**	**1.90**
Real Wage Elasticities	w_l	-1.97	-2.04	-2.02	-.063	-.034	1.45	1.30	1.06	.887	.75
	w_x	-.169	-.141	-.114	-.049	-.046	.053	.064	.065	.066	.066
	w_n	-.276	-.248	-.214	-.047	-.044	-.036	-.032	-.028	-.025	-.022
	w_h	-.297	-.270	-.249	-.278	-.271	-.087	-.070	-.071	-.071	-.072
Duration Elasticities	D_{bl}	-4.00	-4.09	-3.99	-.035	.023	3.16	2.86	2.38	2.01	1.73
	D_{ix}	$4x10^{-5}$	$4x10^{-5}$	$5x10^{-5}$	$8x10^{-5}$	$8x10^{-5}$	$5x10^{-5}$	$5x10^{-5}$	$5x10^{-5}$	$5x10^{-5}$	$6x10^{-5}$