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Temporary Workers, Permanent Workers, and International Trade: Evidence from Japanese firm-level data*

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Abstract

The number of temporary workers in Japan's labor market has increased rapidly since the 1990s. This trend is particularly remarkable in the manufacturing sector, which now relies on sales to foreign markets. This paper formalizes the idea that global competition may encourage manufactures to shift from permanent to temporary workers, proposing a model of multi-product firms motivated to reduce revenue fluctuations. Firms prefer lower sales volatility because of labor adjustment costs. In such a framework, trade liberalization encourages firms to reduce the number of products, which raises the demand for temporary workers because they entail no firing costs. The model is also empirically tested using micro-data from Japanese manufacturing plants. The model's predictions are moderately supported.

Key words: permanent workers, temporary workers, multi products, and international trade
JEL classification: F12, F16

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1 Introduction

The Japanese labor market has witnessed a rapid increase in numbers of temporary workers since the 1990s. Although this trend prevails in most sectors, the shift from permanent to temporary workers has been greater among Japan's manufactures. For example, the proportion of temporary workers among the total manufacturing workforce (the non-permanent ratio) increased from 23.6% in 2001 to 29.4% in 2006, but it increased from 35.2% to 39.0% among all industries during that period. Moreover, the number of permanent employees in Japanese manufacturing fell by approximately 1 million, but the total number of manufacturing employees fell by only 570,000, since the number of dispatched workers and subcontractors rose by 400,000. Approximately 40% of the permanent employees who left manufacturing jobs have been replaced by dispatched workers and subcontractors.[1]

Why are Japanese manufactures aggressively employing more temporary workers? A plausible culprit is the recent deregulation. The Japanese government has relaxed regulations concerning temporary jobs since the late 1990's. Its hallmark was the Worker Dispatching Act in 2004, which reduce restrictions hampering temporary job agencies from dispatching workers to the manufacturers. We acknowledge that deregulation may have influenced the shift from permanent to temporary workers in manufacturing. However, the shift began long before the late 1990's. In addition, it is said that the pressure of globalization has made Japanese companies more attentive to workforce flexibility and more sensitive to employment costs.[2] Thus, it is natural to ask to what extent the documented shift in the workforce is attributable to economic globalization. Few rigorous analyses have sought to verify this causal relationship, and that is our goal.

This paper formalizes the idea that global competition may encourage manufactures to shift from permanent to temporary workers. We test hypotheses derived from our theoretical framework using Japanese plant-level micro-data. For this purpose, we extend the

[1] The authors' calculation is based on the Establishment and Enterprise Census.

[2] In 2004, Nippon Keidanren, Japan's largest lobbying group composed of 1,281 companies and 129 industrial associations, published a report on employment and personnel management. The report claims that labor market flexibility and more aggressive use of temporary workers are vital for firms because of increasing market uncertainty and sales volatility caused stemming from incrementally tough global competition. The report is available at http://www.keidanren.or.jp/japanese/policy/2004/041/honbun.html#s1.

framework of monopolistic competition and heterogeneous firms in Melitz and Ottaviano (2008) by introducing firms' choices between a workforce composed of permanent and temporary workers (Saint-Paul (1997) and others).

The monopolistic competition model proposed by Melitz and Ottaviano (2008) suits our purpose because international trade intensifies competition forcing firms to cut profit margins. In the "dual" labor market model of Saint-Paul (1997), firms optimize their demand for permanent workers, who entail firing costs, and non-permanent (temporary) workers who entail no firing costs. A basic intuition of this framework is that firms use temporary workers to buffer revenue fluctuations and their employment of permanent workers depends on their true cost, that is, the wage plus the expected firing costs.

Our basic idea is as follows. Firms prefer less volatile revenue fluctuations because they expect to save firing costs. Firms become more profitable if they reduce revenue fluctuations. In the model, firms attempt to reduce revenue fluctuations by increasing the number of products, assuming that revenue fluctuations of each product line are uncorrelated. However, it is reasonable to presume that it is more difficult to manage a larger number of products. The firm optimally chooses the scope of its products as the recently increasing multi-product literature suggests (Eckel and Neary (2010), Bernard, Jensen, and Schott (2006), Nocke and Yeaple (2006), and Baldwin and Gu (2006)). In particular, as Nocke and Yeaple (2006), the management capabilities of firms are heterogenous. Thus, the number of products is heterogenous. Firms with more products more effectively smooth revenue fluctuations than firms with few products, resulting in cost diversification across firms for hiring permanent workers. Greater openness in international trade reduces each product's profitability. Thus, firms are forced to concentrate on fewer products which amplifies revenue fluctuations. Thus, firms refrain from hiring permanent workers and prefer temporary workers.

We can derive the following predictions from our model. First, lager firms tend to have more products and lower shares of temporary workers in their workforce than small firms. Second, employment among firms with fewer products (small firms) is more volatile than that among firms with more products (large firms). Third, given that firms use both permanent workers and temporary workers, firms increase total employment by hiring more temporary workers. When total employment increases, the share of temporary workers rises. Finally, when trade costs decline, the share of export sales among total sales rises, and the share of temporary workers comprising labor input rises.

We can observe one of model's predictions in industry-level data. Figure 1 is a scatter chart in which changes in the non-permanent ratio from 2001 to 2006 and the export to production ratio as of 2001 are plotted for each industry in the manufacturing sector. From this, we can observe that industries more reliant on exports in 2001 more aggressively replaced with permanent employees with temporary workers in the years following.

We test these predictions empirically, using plant-level data from the Census of Manufacturing. Our data set covers all manufacturers with four or more employees in 2001-2007. After scrutinizing the data, we find that the evidence moderately supports our model's predictions. First, there is a significant negative correlation between plant size and the temporary worker ratio: in 2001, the temporary worker ratio was is 10.6% for plants with 1000 or more employees and 18.6% for plants with fewer than 100. Second, the average number of products per plant shows a clear positive correlation with plant size. Furthermore, we find that small plants face high volatility in sales. Finally, we find revenue volatility significantly boost the ratio of temporary workers. The model predicts that firms with large changes in the ratio of export sales to total sales also show greater changes in the ratio of temporary workers to all workers. Unfortunately, the data only partially support this prediction.

The remainder of the paper is organized as follows. Section 2 describes the theoretical framework and derives empirically testable hypotheses. Section 3 tests the model's predictions and Section 4 presents the conclusion.

2 Theoretical Framework

This section presents a simple model of dynamic adjustment in which risk-neutral firms can employ both permanent workers with adjustment costs and temporary workers without adjustment costs. The model allows us to derive empirically testable predictions about how international trade affects demand for temporary workers relative to permanent workers. The model is a three-period version of the dynamic labor adjustment model of Saint-Paul (1997) and others. We extend the model by allowing firms to hold multi products and by putting it in the monopolistic competition trade framework of Melitz and Ottaviano (2008).

2.1 Preferences

Consider an economy populated with L households, each of which inelastically supplies one units of labor. The representative consumer maximizes the following quasi-linear utility function based on Melitz and Ottaviano (2008) and Ottaviano, Tabuchi, and Thisse (2002):

$$U = q_0 + \alpha \int_0^N q(\omega) d\omega - \frac{\zeta}{2} \int_0^N [q(\omega)]^2 d\omega - \frac{\eta}{2} \left[\int_0^N q(\omega) d\omega \right]^2, \tag{1}$$

where q_0 and $q(\omega)$ denote individual consumption of the numeraire good and each variety ω of differentiated goods, respectively. N is the measure of the consumed varieties of differentiated goods. Parameters α, ζ, and η are non-negative. Parameter α and η denote the consumer's maximum willingness-to-pay for the differentiated goods: increases in α and decreases in η shift demand from the numeraire good to the differentiated goods. The parameter ζ indexes the degree of product differentiation between the varieties: when $\zeta = 0$, the varieties are perfect substitute. The inverse demand for each variety ω for the individual consumer is given by

$$p(\omega) = \alpha - \zeta q(\omega) - \eta Q, \tag{2}$$

where $Q = \int_0^N q(\omega) d\omega$. By summing (2) for all varieties and deriving the expression for Q, we have the linear market demand function such that

$$q(\omega) = \frac{\alpha L}{\eta N + \zeta} - \frac{L}{\zeta} p(\omega) + \frac{\eta N}{\eta N + \zeta} \frac{L}{\zeta} \bar{p}, \tag{3}$$

where $\bar{p} = (1/N) \int p(\omega) d\omega$ is their average price.

We introduce uncertainty about demand for each variety and assume that the upper boundary of price, $p_{\max}$, beyond which demand for a variety goes to zero, has an error term μ such that

$$p_{\max} = \frac{\zeta \alpha + \eta N \bar{p}}{\eta N + \zeta} + \mu, \tag{4}$$

where the μ is independent and identically distributed (i.i.d.) and follows a normal distribution with mean 0 and variance σ^2. Hence, denoting the upper boundary price $p_{\max}$ by z, z has the mean of $\bar{z} = (\eta N\bar{p} + \alpha\zeta)/(\eta N + \zeta)$ and the variance σ^2. The price elasticity of demand $\epsilon_\omega = |(\partial q(\omega)/\partial p(\omega))(p(\omega)/q(\omega))| = [(p_{\max}/p(\omega)) - 1]^{-1}$ on average. An increase in the number of competing varieties N or a reduction of average prices $\bar{p}$ raises ϵ_ω (a "tougher" competitive environment).

2.2 Sequences of Events

Before proceeding to firms' labor demand, it is useful to establish sequences of events (see Figure 2). At period 0 ($t = 0$), firms randomly draw their management skill ϕ from a common distribution $H(\phi)$. After knowing the management skill level of ϕ, each firm determines its number of products, n. There is no production in period 0, and each firm employs no labor. At the end of period 0, the market size for period 1 ($t = 1$), z_1, is revealed. Each firm determines its total labor inputs and how many permanent workers it employs among them. Production occurs in period 1 at the end of which the market size in period 2 ($t = 2$) is revealed. Each firm adjusts its employment after knowing the realized z_2. If firms decrease inputs of permanent workers, they incur firing costs. There are no such costs for temporary workers. Then, production occurs in period 2.

Since period 2 is the final period, we assume that firms need not dismiss employees. As explained later, in such a situation, firms never employ temporary workers in period 2; this feature merely reflects our assumption about no dismissals of workers at the end of the final period. Thus, we focus on periods 0 and 1. In particular, omitting firms' profits in period 2, we assume that each firm determines its products n based on its expected profit in period 1. Indeed, all important decisions–the number of products, total labor input, and composition of permanent and temporary workers, are made in periods 0 and 1.

2.3 Production

Labor is the single production input for the homogenous good and the differentiated goods. There are two types of workers, who differ in efficiency, wages, and firing costs. The first type, permanent workers, holds long-term contracts without predetermined durations. The second type, temporary workers, holds fixed-duration contracts. It is assumed that permanent workers are more efficient than temporary workers in production of the numeraire good and the differentiated goods.[3]

More specifically, a unit production of the numeraire good requires either $1/w_l$ units of permanent workers or $1/w_s$ units of temporary workers where $w_l > w_s$. The numeraire good is perfectly competitive. Assuming that demand for it is always positive, the wage rates of permanent and temporary workers are w_l and w_s, respectively. We also assume that firms need not incur firing costs for permanent workers in the numeraire good. Thus, firms are indifferent between employing permanent and temporary workers.

In the differentiated goods sector, all varieties of differentiated goods have a common linear production technology. Letting y denote the output of a variety of differentiated goods, a monopolistically competitive firm that employs l units of permanent workers and s units of temporary workers generates $y = l + \lambda s$ where $\lambda < 1$ is an efficiency parameter. It is assumed that the efficiency gap between permanent and temporary workers is more pronounced for differentiated goods than that for the numeraire good. That is, $w_s/\lambda > w$.

Our model departs from the standard monopolistic competition model by introducing labor adjustment costs. In particular, firms must incur firing cost $w_l\gamma$ per worker when they reduce the employment of permanent workers. By contrast, firms can freely disband temporary workers' fixed-duration contracts at any period, as in the numeraire good sector. Note that the assumption of $w_s/\lambda > w$ implies that hiring permanent workers would be less expensive than hiring temporary workers if there were no firing costs.

Each firm faces a linear demand in Equation (3). Redefining parameters, each firm's revenue can be expressed by $r = zy - ay^2/2$ where $a \equiv 2\zeta/L$. Parameter z determines the market size for each product and can fluctuate by numerous reasons, including demand shocks and productivity shocks. The z is i.i.d., and at the end of period 1, firms draw a new z from the distribution of g with the cdf of G and determine their employment level for the second period.

[3] The employment of permanent workers are more protected than that of temporary workers. Hence, permanent workers can be more easily motivated to accumulate firm-specific skill than temporary workers, resulting in relative efficiency superiority in permanent workers.

2.4 Employment Policy

We first consider firms' employment policy, given the number of products n. Firms' employment policy is based on the dynamic labor-adjustment model in Saint-Paul (1997) and others.[4] Suppose that the market size in period 1 is revealed. The firm's expected present discounted profits at period 1 are given by

$$z_1(l_1+\lambda s_1)-\frac{a}{2}(l_1+\lambda s_1)^2-w_l l_1-w_s s_1+E_1\left[z_2 l_2-\frac{a}{2}l_2^2-w_l l_2-w_l\gamma\max\{l_1-l_2,0\}\right], \quad (5)$$

where E_1 represents expectations conditional on information available at $t=1$ and we set the discount rate equal to 1 for simplicity. It should be noted that since period 2 is the final period and the firm needs not alter employment levels at its end, it never uses temporary workers in period 2 (recall the assumption of $w_s/\lambda > w$).

We solve the model from period 2. At the end of period 1, the firm observes a shock on z and determines the employment size at $t=2$ for maximizing profit. Given the level of permanent workers in period 1, l_1, the profit maximization in period 2 is

$$\max_{l_2} z_2 l_2-\frac{a}{2}l_2^2-w_l l_2-w_l\gamma\max\{l_1-l_2,0\}. \quad (6)$$

The first-order condition (FOC) of the problem is as follows:

$$z_2-al_2=w_l(1-\gamma), \quad \text{if} \quad l_2<l_1, \quad (7)$$

$$z_2-al_2=w_l, \quad \text{if} \quad l_2>l_1. \quad (8)$$

The case dependency of the FOC is due to the firing cost. When the firm decreases permanent workers in period 2, it can save w_l, but must pay the firing cost $w_l\gamma$ per worker. When the firm increases permanent workers in period 2, its marginal cost is simply w_l without future firing. The threshold demand shock z_m below which the firm fires workers is obtained by setting $l_2=l_1$ in (7):

$$z_m(l_1)=al_1+w_l(1-\gamma). \quad (9)$$

[4] The labor market with adjustment costs is extensively studied in the labor economics literature. Examples of earlier contributions are Bentolila and Bertola (1990), Bentolila and Saint-Paul (1992) and Bentolila and Saint-Paul (1994). In particular, Bentolila and Saint-Paul (1992) and Bentolila and Saint-Paul (1994) examine labor markets featuring workers with adjustment costs and workers free from adjustment costs. Recent studies based on the framework proposed by these studies include Costain, Jimeno, and Carlos (2010), Ono, Qinghua, and Jin (2010), Aguirregabiria and Alonso-Borrego (2008) and Jin, Ono, and Qinghua (2007)

Likewise, the threshold z_M above which the firm increases workers is given by setting $l_2 = l_1$ in (8):

$$z_M(l_1) = al_1 + w_l. \tag{10}$$

If the shock z is between $z_m(l_1)$ and $z_M(l_1)$, the firm does not alter the number of permanent workers in period 2:

$$l_2 = l_1, \quad \text{if} \quad al_1 + w_l(1-\gamma) < z_2 < al_1 + w_l. \tag{11}$$

The firing cost gives rise to production inefficiency stemming from the range between z_m and z_M where the firm does not adjust its employment level at all: that is, its firing cost is steep even when it does not fire workers in period 2. In addition, it is noteworthy that the employment level in period 2 depends on the employment level in period 1–i.e., there exists *hysteresis*.

We next determine the employment level in period 1. There are two cases. In the first, firms employ both permanent and temporary workers; in the second, only permanent workers. We begin with the first case. The FOC on temporary workers is simple because the employment level in period 1 does not affect employment in period 2. The firm hires temporary workers up to the point where its marginal revenue equals the wage rate w_s:

$$z_1 - a(l_1 + \lambda s_1) = \frac{w_s}{\lambda}. \tag{12}$$

The firm determines its employment of permanent workers in period 1, knowing that permanent workers in period 1 may generate losses in period 2. If the firm dismisses them in period 2, it will incur firing cost $w_l\gamma$ per worker. This is the case when $z_2 < z_m(l_1)$. When z_2 falls between $z_m(l_1)$ and $z_M(l_2)$, the firm must incur production inefficiency $w_l - (z_2 - al_1)$. Thus, the expected firing cost $F(l_1)$ per worker is given by

$$\begin{aligned} F(l_1) &= w_l\gamma G(z_m(l_1)) + \int_{z_m(l_1)}^{z_M(l_1)} [w_l - (z - al_1)]g(z)dz \\ &= \int_{z_m(l_1)}^{z_M(l_1)} G(z)dz \quad \text{(Integrating by parts)}, \end{aligned} \tag{13}$$

which is increasing in l_1. That is, as the firm employs more permanent workers in period 1, it faces a higher expected firing cost in period 2 (see Appendix). Thus, the FOC for permanent workers in period 1 is given by

$$z_1 - a(l_1 + \lambda s_1) = w_l + F(l_1). \tag{14}$$

Notice that the right hand side (RHS) of (14) is increasing in l_1 while the RHS of (12) is constant. Since $w_s\lambda > w_l$, the firm hires permanent workers up to

$$w_l + F(l_1) = \frac{w_s}{\lambda}, \tag{15}$$

which pins down the employment level of permanent workers in period 1. Letting $\bar{l}_1$ be the solution of (15), substituting $\bar{l}_1$ into the FOC for temporary workers in (12) gives the employment level of temporary workers:

$$s_1 = \frac{1}{a\lambda}\left[z_1 - \frac{w_s}{\lambda}\right] - \frac{\bar{l}_1}{\lambda}. \tag{16}$$

The second case is straightforward. Equation (15) indicates that if the market size in period 1 is small and the necessary employment level is below $\bar{l}_1$, then, firms will employ only permanent workers because temporary workers are more costly than permanent workers in such cases. The employment level of permanent workers is determined by the FOC of

$$z_1 - al_1 = w_l + F(l_1). \tag{17}$$

We express the solution to (17) as a function of z_1 such that $l_1^*(z_1)$. The threshold market size z_1 is given by setting $s_1 = 0$ and $l_1 = \bar{l}_1$ in (12):

$$\bar{z}_1 = a\bar{l}_1 + \frac{w_s}{\lambda}, \tag{18}$$

which implies that when $\bar{l}_1$ is high, $\bar{z}_1$ is also high.

Figure 3 depicts the determination of the employment level in period 1. It is clear that the firm primarily uses permanent workers because as long as the expected firing cost is not large, permanent workers are effectively less expensive than temporary workers. At point A, permanent and temporary workers are break even. After point A, the firm switches to hiring temporary workers. Total employment level is given by point B when the market size realized in period 1 is z_1 in the figure. In addition, notice that $\bar{l}_1$ is the upper boundary for the employment of permanent workers. The corresponding market size is $\bar{z}_1$ (not shown). In the figure, z_1' is below $\bar{z}_1$. Thus, the firm hires only permanent workers at the level of l_1' (point D). This is the second case discussed above.

The benefit of using temporary workers is also clear. Suppose that the firm cannot access temporary workers due to, for example, government regulation. In this case, total employment level is determined by point C. The employment level declines, and the marginal production cost rises, compared to the case in which temporary workers are available. Hence, we can observe legitimacy for the Japanese business group's claim for more flexibility in the labor market.

We summarize the employment policy in period 1 as follows:

- There exists an upper boundary for the employment of permanent workers. The upper boundary is implicitly determined by $w_l + F(\bar{l}_1) = w_s/\lambda$. This implies that there is a threshold market size $\bar{z}_1$ above which firms use temporary workers. Such $\bar{z}_1$ is given as a linearly-increasing function of $\bar{l_1}$ such that $\bar{z}_1(\bar{l}_1) = a\bar{l_1} + w_s/\lambda$.

- If $z_1 > \bar{z}_1(\bar{l}_1)$, firms set the employment of permanent workers at $\bar{l}_1$. For fluctuations of z in the rage of $z_1 \geq \bar{z}_1(\bar{l}_1)$, the firm will adjust total employment by altering employment of temporary workers.

- If $z_1 \leq \bar{z}_1(\bar{l}_1)$, firms never hire temporary workers. The total employment of permanent workers is implicitly determined by $z_1 - al_1 = w_l + F(l_1)$.

When firms employ both permanent and temporary workers, the marginal production cost is simply w_s/λ. Therefore, letting μ_1, r_1, and π_1 be the absolute markup, the revenue, and (gross) profit in period 1, respectively, firms set these variables as follows:

$$p_{s1}(z_1) = \frac{1}{2}\left[z_1 + \frac{w_s}{\lambda}\right], \tag{19}$$

$$\mu_{s1}(z_1) = \frac{1}{2}\left[z_1 - \frac{w_s}{\lambda}\right], \tag{20}$$

$$r_{s1}(z_1) = \frac{1}{2a}\left[(z_1)^2 - \left(\frac{w_s}{\lambda}\right)^2\right] \tag{21}$$

$$\pi_{s1}(z_1) = \frac{1}{2a}\left[z_1 - \frac{w_s}{\lambda}\right]^2, \tag{22}$$

where the subscript s indicates that the firm employs both permanent and temporary workers. Likewise, when firms hire only permanent workers, we simply replace w_s/λ with $w_l + F(l_1)$, noticing that l_1 is given by equation (17):

$$p_{l1}(z_1) = \frac{1}{2}\left[z_1 + (w_l + F(l_1^*(z_1)))\right], \tag{23}$$

$$\mu_{l1}(z_1) = \frac{1}{2}\left[z_1 - (w_l + F(l_1^*(z_1)))\right], \tag{24}$$

$$r_{l1}(z_1) = \frac{1}{2a}\left[(z_1)^2 - (w_l + F(l_1^*(z_1)))^2\right] \tag{25}$$

$$\pi_{l1}(z_1) = \frac{1}{2a}\left[z_1 - (w_l + F(l_1^*(z_1)))\right]^2, \tag{26}$$

where the subscript l indicates that the firm employs only permanent workers. Clearly, the expected firing cost $F(l_1)$ declines for all ranges of l_1 as γ goes down. Decreases in γ lower the shadow price of permanent workers,$w_l + F(l_1)$. However, this change does not affect firms' determination of p, μ, r, and π when firms employ both permanent and temporary workers (see Equations (19), (20), (21), and (22)). The upper bound of $\bar{l}_1$ rises, and the ratio of temporary to permanent workers declines as a result. In contrast, when firms use only permanent workers, decreases in γ improve profitability: the price declines while the markup increases. Thus, the revenue and profit go up (see Equations (23), (24), (25), and (26)). These results are recorded as the following proposition:

Proposition 1 (The impact of firing cost)**.** *When the cost of firing permanent workers increases, firms do not alter their total employment level if they employ both permanent and temporary workers. Those firms simply increase the ratio of temporary to permanent workers. In contrast, if firms hire only permanent workers, decreases in the firing costs directly reduce the marginal cost of production, and firms can increase their profits.*

2.5 Multi-product Firms

We now consider the determination of the number of products in period 0. The expected firing cost in Equation (13) reveals why even risk-neutral firms will prefer less volatile sales revenue: less volatile z_2 likely entails a smaller probability of dismissing permanent workers.

In the extreme, if z is deterministic and constant such that $z_1 = z_2$, the expected firing cost is zero, and there is no demand for temporary workers in period 1. Although we need to restrict distribution of z within certain classes, we can establish the following lemma.

Lemma 1. *Suppose that z is normally distributed and that $z_M(l_1)$ is not above the mean of z. Then, a mean-preserving spread of z decreases the employment level of permanent workers in period 1.*

Proof. See Appendix. □

The lemma is quite intuitive. Increasing the number of permanent workers in period 1 leads to a rise in firing costs that the firm may incur in period 2. Thus, if the probability exceeds 50% that firms will hire more workers in period 2, a less volatile z encourages firms to employ more permanent workers in period 1. Indeed, we can show that $z_1 > (z_M(l_1) + z_m(l_1))/2$ (see Appendix). Thus, if we set z_1 at the mean of z, Lemma 1 always holds. In what follows, we focus on situations in which firms prefer less volatile z.[5]

Lemma 1 implies that more stable z leads to a lower expected firing cost for all l_1: $\partial F(l_1, \sigma)/\partial \sigma > 0$. Firms prefer a more stable z because they can produce more efficiently and raise profits when employing only permanent workers (i.e., the realization of z_1 is below $\bar{z}_1$). This creates an incentive for firms to have multiple products for pooling the sales volatility of products in period 0. Recall that z is i.i.d across all varieties: so if a firm has n varieties of the differentiated goods, the average market size per product is still $\bar{z}$, but its variance becomes σ^2/n. Thus, by Lemma 1, the expected firing cost per worker decreases as n becomes large. Hereafter, we denote the expected firing cost per worker by $F(l_1, n)$ where $\partial F(\cdot)/\partial n < 0$ and $\partial F(\cdot)/\partial l_1 > 0$. It is convenient to state the impact of n on some variables discussed above in the following corollary.

Corollary 1. *The upper boundary $\bar{l}_1$ rises as the number of products increases. The threshold market size above which firms start to hire temporary workers, $\bar{z}_1$, also rises.*

[5] The condition that $z_M(l_1)$ does not exceed the mean of z is very strict. It is sufficient that the midpoint between z_m and z_M is not above the mean of z. In contrast, if this condition does not hold, more volatile demand tends to lower the expected firing cost because it increases the chance not to fire employees.

The expected profit per product in period 0, $\tilde{\pi}(n)$ is

$$\tilde{\pi}(n) = \int_{\bar{z}_1(\bar{l}_1(n))}^{\infty} \pi_{s1}(z)g(z)dz + \int_{w_l}^{\bar{z}_1(\bar{l}_1(n))} \pi_{l1}(z,n)g(z)dz. \tag{27}$$

Expected profit per product $\tilde{\pi}(n)$ is increasing in n. Although profit per product is invariant to the number of products when firms employ both permanent and temporary workers, firms hiring only permanent workers can raise their profit per product because they anticipate lower firing costs (proof is straightforward, but tedious). This reduction of production inefficiency stemming from the firing cost via risk diversification is the motivation for firms in our model to increase the number of products. It differs from other motivations for multi-product firms, such as the issue of core competence and cannibalization (Eckel and Neary (2010) and Baldwin and Gu (2006)).

It is assumed that multi-product firms incur a fixed cost in period 0. This fixed cost is rendered as a one-time fixed investment for establishing the management cadre. Thus, this initial investment cost is increasing in the number of products. In addition, we assume that firms' management skills are heterogenous. More specifically, the fixed cost for management require $f(n;\phi)$ units of the numeraire good, depending on firms' management skill ϕ. The management skill ϕ is randomly assigned from a common distribution $H(\phi)$ to each firm when it enters the market. The level of ϕ remains unchanged through all periods. We assume that the management cost satisfy the following three properties. First, unless the number of products exceeds one, the management cost is zero, $f(1;\phi) = 0$. Second, management cost is increasing in n for $n > 1$, $\partial f(n;\phi)/\partial n > 0$, and convex, $\partial^2 f(n;\phi)/\partial n > 0$. Third, holding the number of products constant, the management cost is decreasing in ϕ, $\partial f(n;\phi)/\partial \phi < 0$.

The firm's expected profit per product increases with the number of products. We simply assume that total management cost $nf(n;\phi)$ increases sufficiently fast such that the number of products is finite. We record properties of multi-product firms in the following proposition. The scope of products is determined by maximizing total profits, net of fixed cost for the investment in management. The optimal number of products is given by

$$\tilde{\pi}(n,\phi) + n\frac{\partial \tilde{\pi}}{\partial n}(n,\phi) = f(n;\phi) + n\frac{\partial f}{\partial n}(n;\phi). \tag{28}$$

Figure 4 illustrates the determination of n. The marginal management cost curve for a highly capable firm (M_1) is located below the curve for a less capable firm (M_2). As a result, firms with greater managerial ability (n_1) have more products than firms with lesser managerial ability (n_2).

As discussed, firms hit by the demand shock $z_1 > \bar{z}_1$ employ both permanent and temporary workers. Their per-product performance measures such as output, product prices, markup, revenues, and profits, are unaffected by the number of products. However, firms with more products (large firms) hire more permanent workers than firms with fewer products (small firms). The number of products correlates negatively with the ratio of temporary workers to permanent workers. Firms hit by the demand shock $z_1 \leq \bar{z}_1$ employ only permanent workers. In this case, the number of products affects per-product performance measures. Firms with more products outperform those with fewer products: for any given z_1, firms with more products have lower product prices, higher markups, higher revenues, and higher profits per product.

Figure 5 exhibits the determination of the employment level of permanent and temporary workers per product. In the figure, firm 1 with more products hires more permanent workers (point B) than firm 2 with fewer products (point A) because firm 1 has a lower expected firing cost. However, total employment level per product is the same (point C) because the two firms' marginal production costs are identical. As a result, firm 1 has a lower ratio of temporary workers to permanent workers: $s_1/\bar{l}_1 < s_2/\bar{l}_2$. The impact of temporary workers becomes clearer by comparing the case without temporary workers. In such a case, employment declines and marginal production costs increase at both firms (point D for firm 2 and E for firm 1). In particular, we find that using temporary workers is more beneficial for firms with fewer products (smaller firms).

Based on these discussions, the following properties of multi-product firms are recorded in the following proposition:

Proposition 2. *On average, firms with more products (large firms) enjoy larger outputs, lower product prices, greater markups, greater revenues, and greater profits* per *product than firms with fewer products (small firms).*

Firms with more products (large firms) hire more permanent workers than firms with fewer products (small firms) per product. As a result, firms with more products have lower ratios of temporary workers to permanent workers than firms with fewer products.

2.6 Open Economy

This section considers the impact of international trade on employment of temporary workers. The framework here is based on Melitz and Ottaviano (2008). We assume two symmetric countries, and trade costs between them are the standard iceberg type $\tau > 1$. From the outset, the two countries are engaged in international trade, and a reduction of τ is considered to be trade liberalization.

It is also assumed that the homogenous goods are freely traded between the two countries. Thus, the two countries have the same wage rates for permanent and temporary workers, and these wage rates are unaffected by the reduction of τ. As a consequence, we can apply the discussions in the previous sections to this open economy.

With the demand function in (3), the threshold price p_{max} at which demand for a variety is driven to zero determines the market size and firms' entry and exit. Sine the production technology is linear, we can identify the threshold marginal production cost c_d corresponding to $z = p_{max}$. The firm must exit the market if its marginal cost $w_l + F(n, \phi)$ (or w_s/λ when it employs both temporary and permanent workers) is above z.

Given iceberg trade cost τ, the threshold marginal production cost c_x is given by $c_x = c_d/\tau$. In this sense, exporters are more productive, which is now a broadly supported empirical regularity.[6]

In addition, it is known that decreases in τ lowers c_x (and c_d). As a result, less-productive firms exit the market and average productivity rises (Melitz and Ottaviano (2008)). Such exits can occur in the current model when firms use permanent workers only. Although that seems odd, but it is simply because we assume no heterogeneity in production technology. As long as firms employ temporary workers, all firms can earn the same gross profit per product. However, once we introduce heterogenous production efficiency, it is possible that

[6] See for example, Bernard, Jensen, Redding, and Schott (2007), Mayer and Ottaviano (2007), and Wakasugi, Todo, Sato, Nishioka, Matsuura, Ito, and Tanaka (2008).

even when firms use temporary workers, some less-productive firms exit the market because of the reduction of trade cost.

In sum, starting with a circumstance where the two countries are engaged in international trade, decreases in trade cost reduce the threshold marginal cost ("tougher competition"). In our specification, this is equivalent to the level z dropping permanently. In Figure 4, this change is represented by a downward shift in the marginal gain from increasing products (the dashed curve). As a result, all firms decrease the number of products and raise the expected cots of dismissing permanent workers. Therefore, as a result of lower trade costs, all firms lower the upper-boundary for employing permanent workers and rely more on temporary workers. The ratios of temporary workers to permanent workers rise for all firms (including non-exporters).

3 Empirical Evidence

This section explains our data source and presents some empirical findings related to the theoretical model in the previous section. The model discussed above yields several empirically testable predictions. Those are as follows:

- Lager firms tend to have more products and a lower share of temporary workers than smaller firms.

- Given that firms employ both permanent and temporary workers, firms increase employment by hiring more temporary workers. When total employment increases, the share of temporary workers rises.

- When the trade cost τ declines, both c_d and c_x decline, but c_d declines more than c_x. This implies that an increase in the share of export sales among total sales. The share of temporary workers in total labor input is positively correlated to the share of export sales.

3.1 Data Source

Our data come from the Census of Manufacturer of Japan's Ministry of Economy, Trade and Industry, one of the representative surveys of economic activity. Originating in 1868, the census covers all establishments in all manufacturing sectors. It is conducted for all establishments in calendar years ending in 0, 3, 5 and 8. In other years, it covers establishments with four or more employees. Major items in the census are shipment by products, inventory, book value of equipment and structures, employment, cost of materials, and energy usage. Share of exports among total shipments and detailed information about the composition of employees have been available since 2001.

Since we are interested in relationships among the number of products, volatility of shipments, and the temporary worker ratio at plant-level, we restrict our sample periods between 2001 and 2007. We used data for establishments with 30 or more employees because plants with fewer than 30 employees do not report information on capital stock. Variables of interest are constructed as follows. The number of products is counted in the finest product category available in the data, using 6 digit commodity code. The number of temporary workers is defined as the sum of part-timers, workers dispatched from other companies (mainly temporary help services), and temporary employees (day laborers). The volatility index is the standard deviation of the previous five-year annual growth rate in shipments for each plant.

3.2 Data Overview

Employing the above-introduced dataset, this subsection outlines the characteristics of Japanese manufacturing plants. Table 1 presents the temporary worker ratio by year and plant size as measured by number of employees. Two items are noteworthy. First, there is a significant negative correlation between plant size and the temporary worker ratio. While the temporary worker ratio for plants with 1,000 or more employees was 10.6% in 2001, it was 18.6% for plants with fewer than 100 employees. Second, from 2001 to 2007, larger plants increased their temporary worker ratio more than smaller plants. For example, while the increase in temporary worker ratio for plants with 1,000 or more employees was 10.8%

points, the increase was 4.5% for plants with fewer than 100 employees.

== Table 1 ==

Increases in share of temporary worker show a similar pattern when we examine export share. Table 2 compares share of temporary workers with the share of exports among total shipments. Plants with greater than 75% export intensity raised their temporary worker ratio nearly 10% whereas the increase in the temporary worker ratio was 6% for non-exporters.

== Table 2 ==

Table 3 shows average number of products by plant size. The average number of products per plant correlates with plant size. Plants with 1,000 or more employees produce more than five products on average; plants with fewer than 100 employees produce around two products. This result is consistent with Proposition 1. Moreover, large plants tend to reduce their average number of products. Plants with 1,000 or more employees reduced their average number of products from 5.85 to 4.97 between 2001 and 2007.

== Table 3 ==

As we discussed, if revenues from each product fluctuate, plants with fewer products face a large volatility in total revenues. Table 4 presents average volatility of the growth rate in shipments and shows that small plants face high sales volatility. No clear tendencies emerge for changes in volatility: perhaps, the trend is vulnerable to macro-economic and industry-specific changes.

== Table 4 ==

3.3 Empirical Specification and Estimation Results

To confirm our theoretical hypothesis, we conduct a simple regression analysis. First, we access whether increases in volatility raise the temporary worker ratio ($Temp\_ratio$). The equation to be estimated is

$$Temp\_ratio_{i,t} = \beta_0 + \beta_1 Volatility_{i,t-1} + \nu_i + \mu_{i,t}. \tag{29}$$

Second, we test the effects of reductions in the number of products ($N\_products$) on changes in volatility of shipments. The following simple equation is estimated:

$$Volatility_{i,t} = \beta_0 + \beta_1 N\_products_{i,t-1} + \nu_i + \mu_{i,t}. \tag{30}$$

Third, to investigate effects of competitive pressure on the number of products at each plant, we examine the exporter dummy ($DumExp$) and the share of exports among total shipments (Exp_share). Since exporting plants face foreign competition, we expect that they would reduce the number of products; and the more they ship to foreign markets, the more products they would reduce. We expect the more they ship their products to foreign market, the more products they would reduce.

$$N\_products_{i,t} = \beta_0 + \beta_1 DumExp_{i,t-1} + \beta_2 Exp\_share_{i,t-1} + \nu_i + \mu_{i,t}. \tag{31}$$

We estimate the above three equations with fixed-plant effect and add control variables such as plant scale measured by number of employees ($\log(L)$) and the capital-labor ratio ($\log(K/L)$). All equations are estimated with plant-level data in manufacturing. To check robustness, we compare results for plants that manufacture machinery and equipment with results from plants that export.

Table 5 presents the estimation result for Equation (29). Column (1) shows the results for all manufacturing plants. Column (2) and (3) present results for the machinery and exporting industries. Regardless of sample selection, the main result is qualitatively unchanged. All coefficients for volatility of shipments are negative and significant. That is consistent with our theoretical prediction.

== Table 5 ==

Table 6 presents the relationship between number of products and volatility of shipments. Coefficients for the number of products are negative and significant, suggesting that volatility of shipments decreases as plants reduce the number of products.

== Table 6 ==

Table 7 presents the estimation result for Equation (31). While the coefficient for the export dummy is positive and significant, that for export share is negative and significant. This result suggests that once plants start to export, they tend to increase their number of products, but the beneficial effect diminishes as they increase their export share. Column (4), (5), and (6) add the export share category dummies instead of the export dummy and export share. Since non-exporting plants are the control group, coefficients for export share category dummies present the overall influence of changes in share for each category of export. Results show that while plants with relatively smaller export share–mainly new exporters–tend to increase the number of products, plants with more than a 50% export share are likely to reduce the number of products as export share expands. The positive impact for new exporters was not expected in our theoretical framework. It may reflect the a beginning exporter learns by exporting and introduces different products, but a plant will trim the number of products because of international competitive pressures.

== Table 7 ==

4 Conclusion

Since the 1990s the number of temporary workers in Japan's labor market has rapidly increased. This trend has been remarkable in the manufacturing sector, which increasingly relies on sales to foreign markets. This paper has formalized the idea that global competition may encourage firms to shift their labor demand from permanent to temporary workers. For this purpose, we developed a theoretical framework involving monopolistically competitive firms that employ permanent and temporary workers. In our model, these two types of workers present different adjustment costs if firms fire them. Because of these adjustment costs and revenue uncertainty, firms are incentivized to maintain multiple products to reduce revenue fluctuations per product. However, holding many products is costly because appropriate management becomes difficult. Only firms with exceptional management skills can maintain many products.

International trade or more openness intensifies competition (Melitz and Ottaviano (2008)). As a result, all firms must reduce their number of products, which raises their demand for temporary workers who entail no adjustment costs.

The model is empirically tested using micro-date for Japanese manufacturing plants. We find that the model's predictions are moderately supported.

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Table 1: Temporary Worker Ratio by Plant Size

Scale	2001	2002	2003	2004	2005	2006	2007
30-99	18.6%	19.7%	20.7%	21.7%	22.4%	23.0%	23.1%
100-299	21.3%	23.0%	24.9%	26.0%	26.9%	27.6%	28.3%
300-499	21.2%	23.5%	25.2%	26.6%	27.4%	29.4%	31.0%
500-999	15.8%	19.5%	20.4%	22.3%	23.7%	25.6%	28.3%
1000-	10.6%	11.8%	12.5%	14.7%	15.5%	18.7%	21.3%

Table 2: Temporary Worker Ratio by Year and Export Share

Scale	2001	2002	2003	2004	2005	2006	2007
0%	19.8%	21.3%	22.6%	23.8%	24.5%	25.4%	26.0%
0%<exp≤25%	12.7%	13.9%	15.5%	16.8%	17.7%	18.8%	19.3%
25%<exp≤50%	12.8%	13.1%	14.0%	16.3%	17.5%	18.6%	19.9%
50%<exp≤75%	12.4%	13.7%	14.4%	14.7%	15.6%	16.0%	18.2%
75%<exp	10.5%	10.4%	12.0%	13.8%	13.0%	15.9%	20.1%

Table 3: Average Number of Products by plant size

Scale	2001	2002	2003	2004	2005	2006	2007
30-99	2.04	2.04	2.04	2.03	2.03	2.02	2.18
100-299	2.36	2.37	2.36	2.34	2.32	2.31	2.47
300-499	3.00	3.08	3.03	2.99	2.94	2.89	3.05
500-999	3.51	3.56	3.52	3.53	3.43	3.36	3.40
1000-	5.85	5.92	5.72	5.30	5.32	4.92	4.97

Table 4: Volatility of Shipments by Plant Size

Scale	2001	2002	2003	2004	2005	2006	2007
30-99	0.155	0.158	0.158	0.155	0.154	0.151	0.146
100-299	0.154	0.158	0.157	0.159	0.156	0.150	0.143
300-499	0.150	0.154	0.158	0.156	0.155	0.150	0.145
500-999	0.156	0.158	0.160	0.157	0.158	0.151	0.147
1000-	0.157	0.164	0.163	0.163	0.159	0.155	0.156

Table 5: Regression analysis: Determinants of Temporary Workers

	(1)	(2)	(3)
	Manufacturing	Machinery	Exporting industry
Dep. var	Temp_ratio	Temp_ratio	Temp_ratio
Volatility	0.016	0.0137	0.0132
	[4.46]***	[2.42]**	[2.76]***
log(K/L)	-0.0041	-0.0057	-0.0055
	[-6.61]***	[-5.18]***	[-6.10]***
log(L)	0.0428	0.0462	0.0416
	[28.86]***	[18.91]***	[20.15]***
const	0.0742	0.0318	0.0466
	[8.55]***	[2.13]**	[3.79]***
Year dummy	Yes	Yes	Yes
R2	0.0494	0.0757	0.0692
N	166275	55226	82850

Note: "***", "**" and "*" show 1%, 5%, 10% statistical significance, respectively. Export industry includes chemical products, electric machinery, general machinery, transportation equipment, precision instruments and non-metallic mineral products.

Table 6: Regression analysis: Determinants of Volatility

	(1)	(2)	(3)
Dep. var	Manufacturing Volatility	Machinery Volatility	Exporting industry Volatility
N_products	-0.0009	-0.0013	-0.0009
	[-2.78]***	[-2.51]**	[-2.02]**
log(K/L)	0.0003	0.0006	-0.001
	[0.57]	[0.68]	[-1.32]
log(L)	-0.016	-0.016	-0.0193
	[-14.03]***	[-7.75]***	[-11.41]***
const	0.2166	0.2459	0.252
	[32.40]***	[19.48]***	[25.14]***
Year dummy	Yes	Yes	Yes
R2	0.0118	0.0357	0.0237
N	166275	55226	82850

Note: "***", "**" and "*" show 1%, 5%, 10% statistical significance, respectively. Export industry includes chemical products, electric machinery, general machinery, transportation equipment, precision instruments and non-metallic mineral products.

Table 7: Regression Analysis: Determinants of Number of Products

	(1)	(2)	(3)	(4)	(5)	(6)
	Manufacturing	Machinery	Exporting industry	Manufacturing	Machinery	Exporting industry
Dep. var	N_products	N_products	N_products	N_products	N_products	N_products
Dum_export	0.0736	0.0904	0.0769			
	[7.37]***	[5.47]***	[6.02]***			
exp_share	-0.0019	-0.0023	-0.0022			
	[-5.30]***	[-4.46]***	[-5.14]***			
D(0%<exp_share≤25%)				0.0577	0.0675	0.0584
				[6.29]***	[4.47]***	[5.00]***
D(25%<exp_share≤50%)				0.0397	0.0564	0.0241
				[2.46]**	[2.36]**	[1.26]
D(50%<exp_share≤75%)				-0.0501	-0.0854	-0.0744
				[-2.12]**	[-2.50]**	[-2.71]***
D(75%<exp_share)				-0.0731	-0.0772	-0.0693
				[-1.92]*	[-1.50]	[-1.60]
log(K/L)	-0.0048	-0.0198	-0.0087	-0.0049	-0.02	-0.0089
	[-1.19]	[-2.40]**	[-1.39]	[-1.21]	[-2.43]**	[-1.42]
log(L)	0.1202	0.1336	0.1392	0.1199	0.1331	0.1387
	[12.50]***	[7.27]***	[9.68]***	[12.47]***	[7.25]***	[9.64]***
const	1.884	2.0924	1.9586	1.8851	2.0946	1.961
	[33.56]***	[18.67]***	[22.94]***	[33.58]***	[18.69]***	[22.97]***
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.0182	0.0083	0.0121	0.0182	0.0083	0.0121
N	166275	55226	82850	166275	55226	82850

Note: "***", "**" and "*" show 1%, 5%, 10% statistical significance, respectively. Export industry includes chemical products, electric machinery, general machinery, transportation equipment, precision instruments and non-metallic mineral products.

Table 8: Summary Statistics

stats	N	mean	sd	p25	p75
Volatility	166275	0.153	0.107	0.076	0.201
No. of products	166275	2.288	1.869	1.000	3.000
r_nonreg	166275	0.230	0.232	0.044	0.349
log(K/L)	166275	5.870	1.265	5.249	6.614
log(L)	166275	4.557	0.813	3.951	4.970
Dum_export	166275	0.116	0.321	0.000	0.000
exp_share	166275	2.088	9.173	0.000	0.000

Table 9: Correlation matrix

		[1]	[2]	[3]	[4]	[5]	[6]	[7]
[1]	Volatility	1						
[2]	No. of products	0.0227	1					
[3]	r_nonreg	-0.0037	-0.0737	1				
[4]	log(K/L)	-0.0259	0.1383	-0.2382	1			
[5]	log(L)	0.0006	0.243	0.0628	0.1862	1		
[6]	Dum_export	0.0553	0.1445	-0.0967	0.145	0.2648	1	
[7]	exp_share	0.0805	0.0762	-0.0687	0.1117	0.2376	0.6269	1

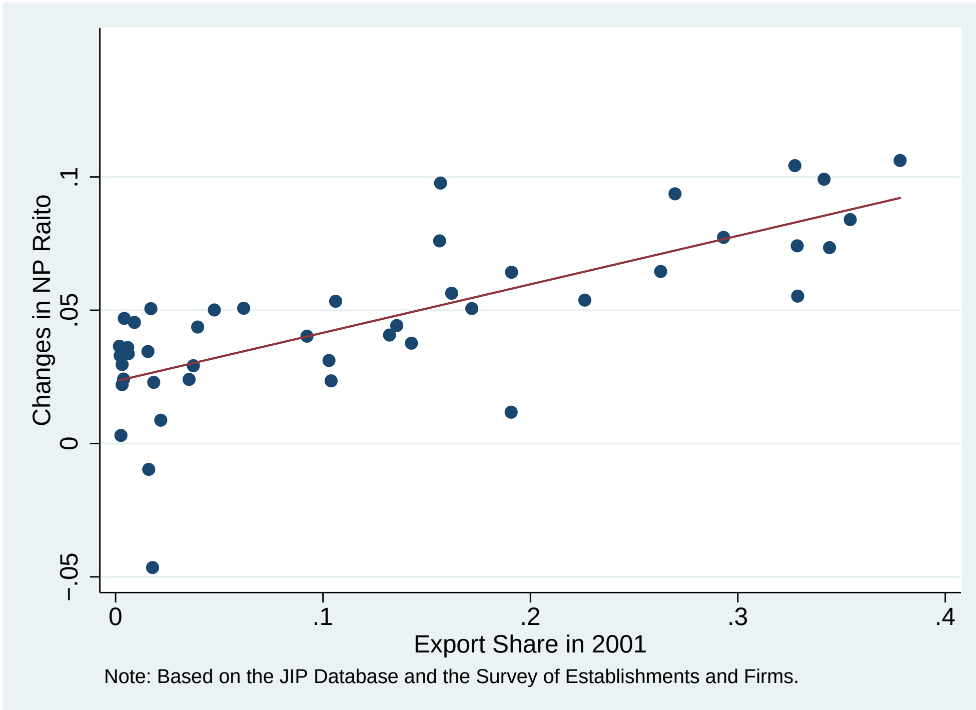

Figure 1: Changes in Non-permanent Ratio and Export Share

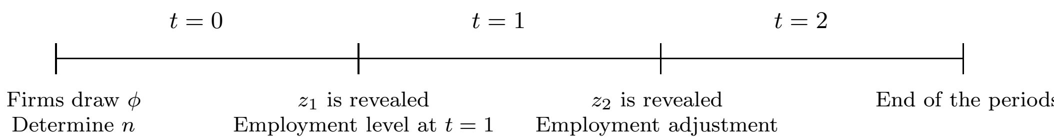

Figure 2: Sequence of Events

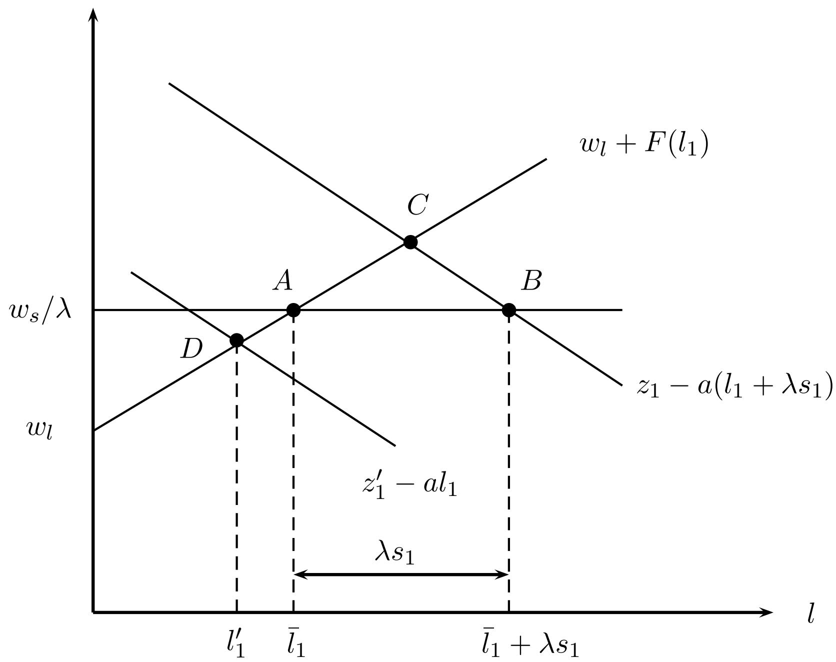

Figure 3: Temporary Workers and Permanent Workers

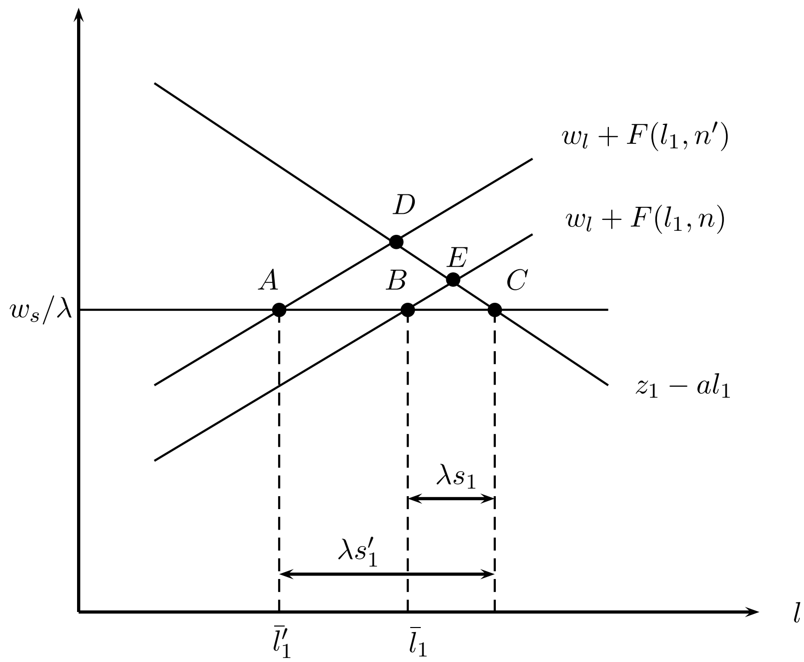

Figure 4: Temporary Workers and Permanent Workers: $n > n'$

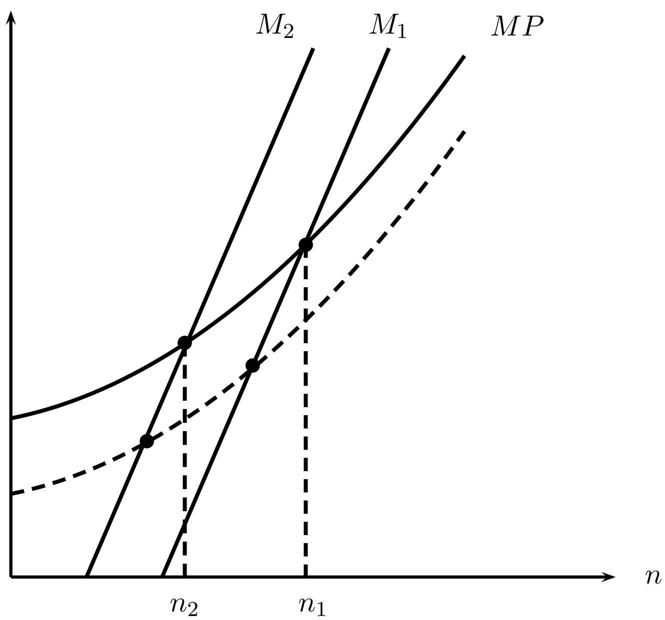

Figure 5: Changes in the Number of Products

A Appendix: Technical notes

A.1 Expected Firing Cost

The expected firing cost can be calculated as follows.

$$\begin{aligned} F(l_1) &= w_l \gamma G(z_m(l_1)) + \int_{z_m(l_1)}^{z_M(l_1)} [w - (z - al_1)] dG(z) \\ &= \int_{z_m(l_1)}^{z_M(l_1)} G(z) dz \quad \text{(Integrating by parts).} \end{aligned} \tag{A.1}$$

Since $G(z)$ is non-decreasing in z and the distance between $z_M(l_1)$ and $z_m(l_1)$ is constant at $w_l\gamma$ and invariant to l_1. Thus, $F(l_1)$ is increasing in l_1.

A.2 Proof of Lemma 1

Totally differentiating Equation (15), we obtain

$$a[G(z_M(l_1)) - G(z_m(l_1))]dl_1 + \left[\int_{z_m(l_1)}^{z_M(l_1)} \frac{\partial}{\partial \sigma} G(z, \sigma) dz \right] d\sigma = 0, \tag{A.2}$$

where σ is the variance parameter of g. Hence,

$$\frac{dl_1}{d\sigma} = -\frac{\int_{z_m(l_1)}^{z_M(l_1)} \frac{\partial}{\partial \sigma} G(z, \sigma) dz}{a[G(z_M(l_1)) - G(z_m(l_1))]}. \tag{A.3}$$

Given the assumptions that $2\bar{z} > z_M(l_1) + z_m(l_1)$, it is the case that

$$\int_{z_m(l_1)}^{z_M(l_1)} \frac{\partial}{\partial \sigma} G(z) dz > 0. \tag{A.4}$$

Thus, $dl_1/d\sigma < 0$.