The Effects of Globalization on Worker Training

Hans Gersbach* and Armin Schmutzler**

This Version: January 2008

ABSTRACT: We study how the integration of product and labor markets affects general worker training. When the number of firms under autarky is not too small and training leads to a sufficiently large productivity increase, integration reduces training, often resulting in lower welfare. We also show that opening product markets to countries with publicly funded training or cheap low-skilled labor can threaten apprenticeship systems.

Keywords: general worker training, human capital, oligopoly, turnover, globalization.

JEL: D43, J24

Affiliations: *CER-ETH – Center of Economic Research at ETH Zurich and CEPR, Zürichbergstrasse 18, 8032 Zürich, Switzerland, e-mail: hgersbach@ethz.ch

**Armin Schmutzler (corresponding author), SOI, University of Zurich, Blümlisalpstr. 10, 8006 Zurich, Switzerland, arminsch@soi.unizh.ch.

1

1 Introduction

The level of general worker training has decreased recently in some countries, including Germany. For instance, between 1985 and the turn of the century, the number of apprentices in West Germany declined by almost 30 percent. This decline can only partly be attributed to a declining population in the relevant age brackets and to increasing levels of university-entrance qualification.[1] In this paper we therefore offer an alternative explanation. We suggest that the decline may be related to the increasing integration of German product markets into the European and World economy which has taken place over the last decades.

To this end, we develop a model where, in the first stage, firms can invest in productivity-enhancing training that is useful both within the firm and in the competing firms. Then they make wage offers for each others' trained workers. Finally, product-market competition takes place. When two product markets become integrated, that is, replaced by a single market, there are three effects on firms' incentives to train their workers. First, market size increases, which raises each firms' incentives to invest in training. Second, the number of competitors increases, which reduces training investments. Third, competition for trained workers increases, which tends to raise their wage and makes training less attractive. As a result, if the national product markets are relatively small and populated by few firms, integration fosters training, whereas the opposite occurs when larger product markets with a higher number of firms integrate. This last statement is the most interesting implication of our analysis: For a wide range of parameter values, integration reduces training.

The implied effects of integration on welfare are striking. If integration destroys the training equilibrium, it often reduces welfare. Even though integration reduces mark-ups and leads to savings in training costs, the negative welfare effect due to lower productivity dominates. However, if integration

---

[1]See, for example, Euwals and Winkelmann 2001, Franz and Soskice 1995.

2

does not affect training, or even fosters training, welfare will improve.

We extend our analysis in two directions. First, we examine competition in product markets from countries with alternative training institutions. For example, countries with apprenticeship systems, such as Germany, face competition from countries with vocational schooling systems or countries with low-skill workers. We show that such competition is indeed a threat to apprenticeship systems: The negative effects of globalization on training are more pronounced than when countries are symmetric. Second, we examine the robustness of our findings with regard to entry and exit of firms after integration. We show that our conclusions continue to hold when the number of firms is endogenized before and after product-market integration through sunk entry costs. We also show that when the fixed costs of operation are not sunk (so that firms might want to exit after integration), integration may still destroy training, even though the potential shake-out of firms induces countervailing effects.

Overall, the paper identifies new effects of market integration on firm training which can inform the current policy debate in Europe on whether and how to redesign apprenticeship systems. One of the proposals is to reduce the remuneration of apprentices in order to increase the incentives of firms to train.[2] The analysis suggests that, without such measures, the apprenticeship system might come under further pressure.

Existing theoretical papers on the relation between globalization and human capital accumulation concentrate on *workers'* incentives to acquire human capital, arguing that globalization affects both workers' returns to education and its costs. This literature comes to mixed conclusions about the effects of globalization on human capital accumulation. For instance, the work of Rodrik (1997) and Kim and Kim (2000) suggests that globalization should increase general human capital investment relative to sector-specific investment.[3] Several authors deal specifically with the effects of globalization

---

[2]Such proposals have for instance been advocated by the president of the industry association DIHK, Georg Braun (Die Welt, July 30, 2005).

[3]Uncertainty about sector-specific shocks brought about by globalization may reduce

on training in developing countries, mentioning both negative and positive influences.[4]

Contrary to earlier literature, we focus on *firms'* incentives to finance such training. We develop the argument that integration of large product markets reduces training, and we offer a new explanation why such integration puts pressure on apprenticeship systems.[5]

The paper is organized as follows. Section 2 introduces the model for the autarky case and provides conditions for training equilibria. Section 3 analyzes how globalization, that is, the simultaneous integration of labor and product markets, affects the chances that training equilibria will arise. In Section 4 we explore the effects of globalization on welfare and distribution. Section 5 extends the analysis to countries with asymmetric training systems. In Section 6, we discuss the robustness of our findings to endogenous entry and exit. Section 7 concludes.

2   The model

Our analysis of the effects of integration relies on a model of general worker training that we now develop for the case of a single country.[6] Later we will

---

the incentives to acquire sector-specific skills. General human capital investment, on the other hand, allows workers to adjust easily to sectoral shocks.

[4]Cartiglia (1997) emphasizes that, because trade has income effects, it relaxes liquidity constraints, and thus increases workers' ability to invest in education. Further, he notes that by increasing the relative wages of skilled workers, trade openness increases the costs of education. Chuang (1998) argues that exports themselves promote learning. Wood and Ridao-Cano (1999) show that, in developing countries, where skilled labor is relatively scarce, the opening of the world market reduces the incentive to invest in skills relative to developed countries. A negative relation between openness and human-capital investments has also been postulated by Findlay and Kierzkowski (1983) and Stokey (1991).

[5]A precursor of our analysis can be found in Gersbach and Schmutzler (2003).

[6]There is a voluminous literature on reasons why firms engage in general training, even though without frictions on labor or product markets they have no incentive to do so. Acemoglu and Pischke (1999) provide an insightful survey of the arguments.

study integration of two countries. The model comprises three stages. In the first stage, firms $i = 1, ..., I$ simultaneously choose their general human capital investment levels $g_i \in \{0, 1\}$.[7] The firm incurs training costs $T > 0$. G denotes the total number of trained workers or, equivalently, the number of firms that train their workers.

In the second stage, after having observed each others' training decisions, firms $i \in \{1, ..., I\}$ simultaneously offers wages w_{ij}, $j \in \{1, ..., G\}$ for all the trained workers in the market. If firm j has not trained, that is, $g_j = 0$, wages are $w_{ij} = 0$, $i = 1 \ldots I$. Thus, (i) we normalize the wages of workers without training to zero; (ii) we assume that the wage of a worker without training is also the reservation wage for the trained workers, that is, their knowledge is useless outside the industry under consideration. After having obtained the wage offers, each employee accepts the highest offer.[8] Denote the number of trained workers in firm i at the end of the second stage as t_i. Hence $\sum_{i=1}^{n} t_i = G$.

In the third stage, the I firms are Cournot competitors, producing homogeneous goods, with inverse demand $p = a - bx$, where x is output, p is price and a and b are positive constants. Marginal costs c_i are a decreasing function $c(g_i)$ of the number of trained workers in a firm that we specify as

$$c_i = c(t_i) = \frac{c}{\delta t_i + 1} \text{ for some } \delta > 0. \tag{1}$$

The firm incurs training costs $T > 0$.

We distinguish between *net profits* and *gross profits*, according to whether or not wages for trained workers are deducted. We define the *long-term payoff* as the difference between net profits and training expenses. Finally, we define

---

[7] It is best to think of firms as either having one worker each or a team of workers such that their human capital investments are perfect complements, education is only valuable if the entire team is educated.

[8] As a tie-breaking rule, we use the convention that the employee stays with his original firm if this firm offers the highest wages. Moreover, the turnover game has the structure of an auction with externalities where multiple auctioneers (the workers) auction themselves to multiple bidders (the firms).

the *product market subgames* as the subgames starting in Period 3 and the *turnover subgames* as the subgames starting in Period 2. We write $\pi_i(t_i, \mathbf{t}_{-i})$ for the gross profit that firm i realizes in stage 3; where $\mathbf{t}_{-i}$ is the vector of workers trained by all firms except i. We summarize the game in Table 1.

Table 1: **Game Structure**

Stage 1:	Firms $i = 1, ..., I$ choose training levels g_i.
Stage 2:	(i) Firms choose wage offers $w_{i,j}$ for all $i, j \in \{1, 2, ..., I\}$.
	(ii) Workers choose between employers, thus determining the numbers t_i of trained workers.
Stage 3:	Product market competition with gross profits $\pi_i(t_i, \mathbf{t}_{-i})$.

Applying standard formulas for Cournot competition with heterogeneous firms,

$$\pi_i(t_i, \mathbf{t}_{-i}) = \frac{1}{b(I+1)^2}\left(a - Ic(t_i) + \sum_{j \neq i} c(t_j)\right)^2. \tag{2}$$

It will turn out that, for all the cases we need to consider, $\pi_i(t_i, \mathbf{t}_{-i})$ can be regarded as a function of t_i and G only. To see this, first suppose $G - t_i \leq I - 1$. Then the remaining firms have at most one worker, and we write $\pi_i(t_i, G)$ for the profits $\pi_i(t_i, \mathbf{t}_{-i})$ in the case where firm i has t_i trained workers and $\mathbf{t}_{-i}$ is such that $G - t_i$ firms have one trained worker and the remaining firms have no trained worker. Next suppose $G - t_i > I - 1$. Then at least one of the remaining firms has more than one worker. However, we will only require the special case that exactly one competitor has more than one worker. In this special case, $\pi_i(t_i, G)$ refers to the profits $\pi_i(t_i, \mathbf{t}_{-i})$ such that firm i has t_i workers, $I - 2$ of the competitors have 1 worker, and one competitor has the remaining $G - (I - 2) - t_i$ workers.

Finally, for later reference, note that the equilibrium price is

$$p = \frac{1}{(I+1)}\left(a + \sum_{j=1}^{I} c_j(t_j)\right). \tag{3}$$

6

2.1 Main theorem

We now provide sufficient conditions for a *training equilibrium* where each firm engages in training. Throughout the paper, we focus on situations with decreasing returns to poaching additional workers. This assumption will be discussed precisely in Appendix A. For now, it is sufficient to note that it implies that the value of having one trained worker rather than none is higher than the value of having two trained workers rather than one, that is,

$$\pi(1, I) - \pi(0, I) \geq \pi(2, I) - \pi(1, I). \tag{4}$$

Using the assumption of decreasing returns to poaching, we can deduce our main result, which will be seen to have a straightforward interpretation.

Theorem 1 *(i) A training equilibrium exists if*

$$\theta(I) \equiv 2\pi(1, I) - \pi(2, I) - \pi(0, I - 1) \geq T. \tag{5}$$

(ii) In this equilibrium, each firm trains one worker. The trained worker stays with the firm and receives the wage

$$w^* = \pi(2, I) - \pi(1, I).$$

The formal proof of the theorem is given in Appendix A. We now provide the main intuition, which follows from three observations.

Observation 1: *Suppose each firm has trained one worker in period 1. Moreover, suppose that (4) holds. Then there is an equilibrium of the turnover game where each worker is offered w^*.*

To see the intuition of the observation, note that w^* is the willingness of each firm to pay for a second worker. Our assumption of decreasing returns to poaching says that, for a firm with one trained worker, w^* is lower than the willingness to pay to prevent poaching of the first worker, $\pi(1, I) - \pi(0, I)$. Hence, poaching will be prevented in equilibrium by offering the willingness to pay for a second worker as a wage. Thus, each firm is willing to offer $w^* = \pi(2, I) - \pi(1, I)$, and there is no turnover.

Observation 2: *Suppose a firm deviates from training. Then, in the resulting subgame, each firm obtains a net payoff of $\pi(0, I-1)$, no matter whether it has a trained worker or not. The equilibrium wages are*

$$\pi(1, I-1) - \pi(0, I-1).$$

Intuitively, the firm without a trained worker obtains a gross payoff $\pi(0, I-1)$, which is also its net payoff, whereas the remaining firms obtain $\pi(1, I-1)$. Equilibrium wages must exactly make up for this difference.

The equilibrium condition (5) guarantees that wages in the training equilibrium are lower than if one firms refrains from training. This corresponds to the intuition that trained workers are not as scarce and therefore less valuable if there are more trained workers.[9]

Observation 3: *In the suggested equilibrium, all firms earn long-term payoffs*

$$\pi(1, I) - w^* - T.$$

This is obvious, as $\pi(1, I)$ corresponds to gross profits in the proposed equilibrium, w^* is the wage and training costs are T. Putting these three observations together gives the result.

We also note some important additional important properties of the equilibrium structure, both of which are proven in the working paper (Gersbach and Schmutzler 2004). First, there always exists an equilibrium where no firms trains. Thus, whenever there is a training equilibrium, there are multiple equilibria, and there is an issue whether firms will coordinate on the training equilibrium. Second, there are no asymmetric equilibria where some firms engage in training whereas others do not. Finally, we show in the working paper that conditions (5) and (**??**) are also necessary conditions for the existence of training equilibria.

---

[9]The wage after deviation, $\pi(1, I-1) - \pi(0, I-1)$, is greater than $\pi(1, I) - \pi(0, I-1)$, which, in turn, is bounded below by $\pi(2, I) - \pi(1, I) + T$ when (5) holds and hence by the wage $\pi(2, I) - \pi(1, I)$ in the training equilibrium.
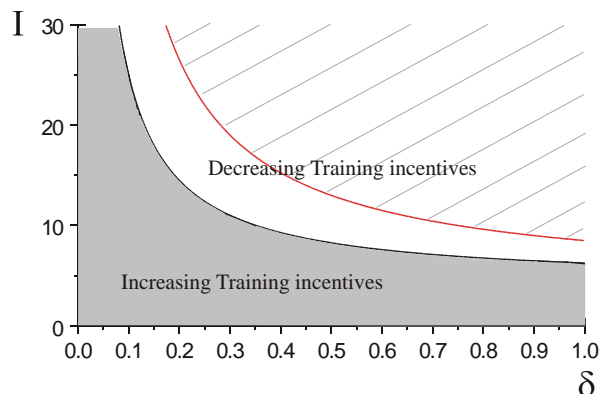
Figure 1: The Effects of Globalization on Training Incentives

3 The effects of globalization on training

We now analyze the effects of integrating labor and product markets of two countries which are characterized by identical values of parameters a, c, δ, b and I. After integration, there is only one market. On this market, there are $2I$ firms. Total demand results from horizontal addition of the two national demand curves $p = a - bx$, so that the inverse demand is $p = a - \frac{b}{2}x$.

Inserting the terms for the profit functions in Appendix C into (5), it is easy to calculate the net training incentives before and after integration, θ^I and θ^{2I}, for general parameter values. In the following, suppose $a = 10$, $b = 1$, $c = 1$. The left line in Figure 1 separates combinations of δ and I for which net training incentives are positive from those where they are negative.

Thus, when the initial number of firms I is high and training leads to a substantial cost reduction (δ is high), globalization potentially has a negative effect on training: There are two reasons why this may happen even though the greater size of the market resulting from integration works in favor of higher demand. First, the higher number of competitors reduces training incentives. Second, increasing competition for trained workers tends to raise wages and makes training investments less attractive. Of course, when train-

ing costs are sufficiently low, condition (5) may still hold after integration, even when $\theta(I) > \theta(2I)$. However, when $\theta(I) \geq T > \theta(2I)$, the equilibrium breaks down. Conversely, when the initial number of firms is low and training only has small cost effects, globalization may have a positive effect on training: If $\theta(2I) \geq T > \theta(I)$, integration induces a training equilibrium.

As integration corresponds to the simultaneous integration of product and labor markets, one might ask whether both types of integration play a role in generating the pattern just described. In the working paper (Gersbach and Schmutzler 2004), we show that the main effects come from the integration of product rather than labor markets. To see this, we consider a modified game where labor markets are integrated, but product markets are not. The only substantial difference between this game and the autarky game described in Section 2 is that in the game with integrated labor markets each firm can also poach abroad: In terms of profit effects, foreign and home-country workers are not perfect substitutes, although trained workers generate the same cost reduction irrespective of the country where they received training. Hence, poaching at home is more attractive because it raises rivals' costs, and a firm will only poach abroad if it already employs all home-country workers. As a consequence, the additional poaching opportunities with labor market integration are likely to be irrelevant. Therefore it turns out that the equilibrium under pure labor market integration exists under very similar conditions than the equilibrium under autarky.

4 Welfare effects of full integration

We now compare welfare, defined as the sum of consumer surplus, producer surplus and workers' rents before and after integration of two identical countries. Welfare effects consist of the standard direct effect of market integration (resulting in lower prices) and effects related to a change in training activities. As argued in the preceding section, such an effect need not necessarily occur, and if it does, it can be positive or negative. Accordingly, we

address each possibility in turn. We use the notation $P_I(T)$ $(P_{2I}(T))$ to denote prices in the training equilibrium before (after) integration, and $P_I(0)$, $P_{2I}(0)$ for prices in the no-training equilibrium. The formulas are given in Appendix C.

4.1   Case 1: Unchanged training behavior

We first consider the case that integration does not affect training.

Proposition 1 *If integration does not affect training behavior, it*
(i) increases welfare;
(ii) raises wages of trained workers for sufficiently large values of I
(iii) reduces gross profits.

　　Proof. See Appendix C. ∎

　　Intuitively, when integration does not affect training, its only impact on aggregate welfare is the price effect, which benefits consumers and hurts producers, and is positive in the aggregate. Note, however, that firms not only suffer from lower prices, but potentially also from higher wages for trained workers. This wage effect is consistent with Feenstra and Hanson (2001) who provide evidence for an increase of skilled wages as a result of globalization. The effect results from an increase in labor demand brought about by integration: Increasing product market competition makes trained employees more valuable.

4.2   Case 2: Integration induces training

Next, suppose integration induces training.

Proposition 2 *Suppose that before integration no training equilibrium exists, but after integration it does. Suppose integration induces training.*
(i) Then prices fall, and consumers and trained workers benefit.
(ii) Profits will only fall if firms select a payoff-dominated equilibrium after integration.

Proof. (i) $P_{2I}(T) < P_I(0)$ as $P_{2I}(T) < P_I(T)$ and $P_I(T) < P_I(0)$.
(ii) follows immediately from (i). ∎

If integration induces training, both the competition effect of integration described in Proposition 1 and lower costs work towards lower prices. In principle, the resulting increase in consumer surplus could be compensated by a lower producer surplus, but this can only happen when firms switch to a payoff-dominated equilibrium after integration.[10]

4.3 Case 3: Integration destroys training

When integration destroys training, integration may reduce welfare. Apart from the obvious fact that reductions in training expenses have a positive ceteris paribus effect on welfare, there are ambiguous price effects. The absence of training increases marginal costs, but competition reduces markups.

Proposition 3 *Suppose that a training equilibrium exists and is selected before integration, but not afterwards.*

(i) Prices fall as a result of integration if and only if

$$a > A^* := \frac{c}{1+\delta}(1 + 2\delta(I+1))$$

(ii) If $a > A^*$, integration increases welfare.

Proof. See Appendix C. ∎

If $a > A^*$, the mark-up reduction resulting from integration dominates over the higher marginal costs caused by untrained workers. As prices are lower and training costs are saved, welfare must increase. If $a < A^*$, however, integration may reduce welfare. Intuitively, the higher marginal costs after integration outweigh the lower mark-up and the savings in training expenses. The shaded area in Figure 1 depicts such parameter regions.

---

[10]Moreover, as we show in Gersbach and Schmutzler (2004), even when the possibility that firms switch to payoff-dominated equilibria is taken into account, welfare increases for a large set of parameters.

5   Different training systems

Until now we have analyzed the impact of globalization when firms in both countries have access to the same training technologies. Countries differ, however, in this respect (Ryan 2001). We therefore ask how global competition between countries with different training systems affects training incentives, focussing on apprenticeship systems of the German type. The existing literature largely concludes that firms are willing to pay a share of the training costs, although the apprentices mainly acquire general skills.[11]

The *Systems Competition Game (SCG)* is described as follows. We suppose in country 1 there are $I \geq 2$ firms in the market who all train their workers as in the basic model, whereas in country 2 there are two possibilities. In the first case, firms use workers whose training is publicly funded, so that there are I firms with identical marginal costs of $c_i = \frac{c}{\delta+1}$. In the second case, country 2 has only low-skilled workers. The product market is integrated. Finally, we assume that labor is mobile only within national borders. Firms from countries 1 and 2 compete in a global market place. For both cases in the SCG, profits of firms in country 1 are described by the notation $\tilde{\pi}_i(t_i, G)$ with the same conventions as in Section 2. $\tilde{\pi}_i(t_i, G)$ is the profit of firm i if it has t_i trained workers, and $G - t_i$ trained workers are employed by national competitors.[12]

Proposition 4 *A training equilibrium in the SCG exists if the following conditions hold:*

$$2\tilde{\pi}(1, I) - \tilde{\pi}(2, I) - \tilde{\pi}(0, I-1) \geq T; \tag{6}$$
$$\tilde{\pi}(1, I-1) - \tilde{\pi}(0, I-1) \geq \tilde{\pi}(2, I-1) - \tilde{\pi}(1, I-1).$$

The proof is analogous to Theorem 1.

---

[11]See Franz and Soskice 1995, Harhoff and Kane 1997, Acemoglu and Pischke 1998, Euwals and Winkelmann 2001, Clark and Fahr 2001.

[12]In the case with publicly funded training in the other country, there are of course $G + I$ trained workers in the entire world market.
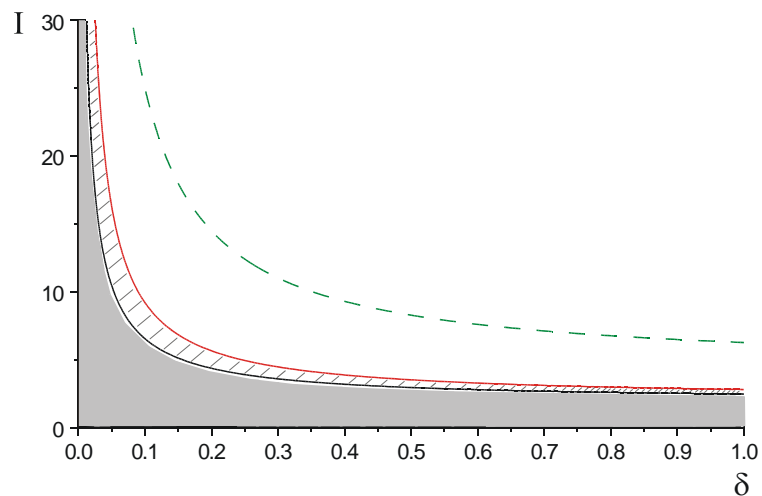
Figure 2: The Effects of Globalization with Competing Training Institutions

We now present some simple illustrations for the effects of international competition between training systems.[13]   As before, parameter values are $a = 10$, $b = 1$, $c = 1$.

The dark area in Figure 2 depicts the parameter region for which integration has a positive influence on training incentives for both variants of the training game. In the shaded area, the influence is positive only for the case of sponsored training, not with low-skilled workers. For the remaining parameter values, the impact of globalization on training is negative in both cases. For both variants of the *SCG,* the parameter region where globalization has a negative impact on training is larger than in the standard game, for which the negative effects occur only to the right of the dashed line.

Euwals and Winkelmann (2001) explain the decline in the number of apprentices over the last decade in Germany with demographic and compositional factors. Our theoretical analysis suggests that globalization might have accelerated the decline of the apprenticeship system. With such forces

---

[13]In Appendix 3, we list all relevant payoff functions.

undermining the sustainability of the system, education policy faces the difficult decision of whether or not to give incentives to stabilize the system.

6   Robustness

Our approach relies on several simplifying assumptions. In particular, we treated the number of firms as fixed, so that the number of firms in the integrated market is simply the total number of firms in the non-integrated markets. The simplest way to account for an endogenous number of firms can be sketched as follows.

Suppose that, under autarky, firms choose whether to enter the market at a fixed cost before playing the national training game involving the three stages as before (training decisions, wage determination and product market competition).[14] Throughout this *pre-integration game*, the firms do not anticipate that integration will occur.

In the simplest case, suppose that all fixed costs will be sunk after entry. Then, the pre-integration game determines the number of active firms in the national markets by the requirements that (i) discounted payoffs have to cover entry costs and (ii) additional entry would lead to long-term payoffs below the fixed costs. Suppose that after the national training game has been completed, integration takes place. In the first stage of the *post-integration game*, incumbent firms from the national markets may decide to exit, and new firms may decide to enter. Afterwards the global training game takes place. It is obvious that no firm will exit, as entry costs are sunk. Thus, by staying in the market and abstaining from training, a non-negative profit can be guaranteed. As shown formally in the working paper (Gersbach and Schmutzler 2004), one of the two following cases arises. Either no further entry takes place, so that our conclusion derived under the assumption of an unchanged number of firms still holds, or entry may take place, which

---

[14]The analysis can easily be extended to the case that firms play finite repetitions of the training game after entry decisions have been made.
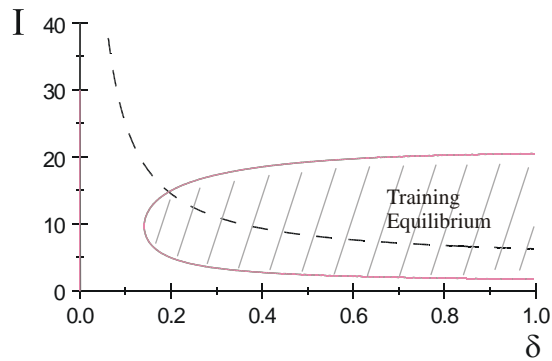
Figure 3: The Effects of Globalization on Training with Endogenous Entry

reinforces the threat to training coming from market integration.

An important modification of the approach allows for the possibility that remaining in the market after integration involves further fixed costs. For simplicity, suppose that after integration, there is a single stage where firms decide whether to remain in the market at an additional fixed cost, before the training game is played with the remaining firms. In this setting, integration can induce a shake-out of firms, because per-firm profits (gross of fixed costs) in the integrated market are smaller than in the national markets if all firms remained in the market. This shakeout can increase incentives for training. In spite of this potential countervailing effect, the idea that integration can destroy training is still relevant in this context. To see this, suppose for simplicity that training costs are very low. The shaded area in Figure 3 corresponds to the combinations of δ and I for which a training equilibrium arises in the polar case that $T = 0$.[15]

Suppose that, for some δ, the number of firms is so high that training arises for (δ, I), but not for $(\delta, I + 1)$.[16] Thus, because the training equilibrium no longer arises for $I + 1$ firms or more, the training equilibrium not

---

[15]The area above the dashed line corresponds to situations where integration reduces net training incentives.

[16]An example is $\delta = 0.5$; $I = 19$.

only breaks down when the number of firms is $2I$, but also when a shake-out following integration leads to a reduction in the number of firms to any value between $I + 1$ and $2I$. Hence, even though such a shake-out may well affect training incentives positive, the insight that integration can have an adverse effect on training survives. To repeat, the main condition for the robustness of the destruction of training in spite of the shake-out is that the original constellation is sufficiently close to the upper boundary of the training region, so that the incentives to deviate from the training equilibrium are already fairly strong under autarky. When the initial situation corresponds to a point further in the interior of the training region, it is possible that the shake-out leads to post-integration equilibrium with training, even when training would be destroyed with a fixed number of firms.

These considerations point to an important conclusion: Whether training will actually destroy the training equilibrium is likely to depend on characteristics of the particular industry. Specifically, in industries where fixed costs remain particularly important after entry (so that a substantial shake-out may arise), training may be under less pressure than in industries where entry costs dominate.

7   Conclusions

Our paper makes the following main points: First, the effects of product market integration on training incentives are positive when the initial market concentration is high and negative when it is low. Second, when integration destroys training, the net effect on welfare tends to be negative. Third, systems competition might undermine training systems. Fourth, when integration leads to a substantial shake-out of firms, this may prevent the reduction in training activities. These findings can potentially inform the policy debate about the causes and remedies when training systems come under pressure as a consequence of market integration.

8 Appendices

8.1 Appendix A: Proof of Theorem 1

We first make our assumption of decreasing returns to poaching workers more precise. Literally, the assumption would mean that $\pi(t_i + 1, I) - \pi(t_i, I)$ is decreasing in t_i. In fact, we require only the following weaker assumption.

Assumption 2

$$\max_{t_i \in \{3,\dots,I\}} \frac{\pi(t_i, I) - \pi(1, I)}{t_i - 1} \leq \pi(2, I) - \pi(1, I); \tag{7}$$

$$\max_{t_i \in \{2,\dots,I-1\}} \frac{\pi(t_i, I-1) - \pi(1, I-1)}{t_i - 1} \leq \pi(1, I-1) - \pi(0, I-1) \tag{8}$$

The left hand sides of equations (7) and (8) are average effects of trained workers on gross profits, whereas the right hand sides are marginal effects. Clearly, Assumption 2 holds if the marginal productivity of poaching is decreasing in t_i. We note that condition (5) implies decreeasing returns to poaching when a firm considers to hire a second worker. Indeed condition (5) implies $\pi(1, I) - \pi(0, I-1) \geq \pi(2, I) - \pi(1, I)$, and therefore $\pi(1, I) - \pi(0, I) \geq \pi(2, I) - \pi(1, I)$. Hence, there are decreasing marginal returns to poaching. Condition (8) also reflects dereasing marginal returns to poaching, with $I - 1$ rather than I.

To prove Theorem 1, we need to formulate observations 1 and 2 more carefully and prove them.

Proposition 5 *Suppose each firm has trained one worker in period 1.*
(a) Suppose (5) holds. Then there is an equilibrium of the turnover game where the highest wage offer for each worker is $w^* = \pi(2, I) - \pi(1, I)$.[17] In

---

[17] The equilibrium is supported by wage offers $w_{ij} = w^*$, $i = 1, \dots, I$ and $j = 1, \dots, I$, or alternatively, by wage offers w^* to only two workers, i.e., $w_{ii} = w^*$, $w_{ii+1} = w^*$ for $i = 1, \dots, I - 1$ and $w_{I1} = w^*$, $w_{II} = w^*$ and zero wage offers in all other cases.

any equilibrium each firm employs exactly one trained worker.

(b) Suppose that

$$\pi\left(1, I\right) - \pi\left(0, I\right) < \pi\left(2, I\right) - \pi\left(1, I\right).$$

Then, in any subgame perfect equilibrium in pure strategies, there is at least one firm without a trained worker. In equilibrium, this firm cannot have lower net profits than any firm with a trained worker.[18]

Proof. First, we show that, if (5) and (8) hold, there is indeed an equilibrium such that each worker is offered w^* by each firm, and therefore each firm employs exactly one worker at the end of the turnover game. By (5, the gross profit reduction from having no trained worker instead of one outweighs the reduction in wage payments w^*, so that reducing the wage offer is not a profitable deviation. Conversely, to attract $t_i - 1$ more trained workers, a firm has to offer them wages slightly above w^*, leading to gross profits $\pi\left(t_i, I\right)$ and wages of approximately $\pi\left(2, I\right) - \pi\left(1, I\right)$ per worker. The relevant non-deviation condition is thus

$$\pi\left(t_i, I\right) - \pi\left(1, I\right) \le \left(t_i - 1\right)\left[\pi\left(2, I\right) - \pi\left(1, I\right)\right] \text{ for } t_i \ge 2. \qquad (9)$$

Clearly, (7) and (9) are equivalent. Hence, attracting more workers is not profitable.

Next, suppose that, in equilibrium, one firm (say firm 1) has at least two workers, whereas some other firms have none. The equilibrium wage must be at least $\pi\left(1, I\right) - \pi\left(0, I\right)$, as this is the wage offer a firm without trained workers is willing to make. Net profits of firm i are $\pi\left(2, I\right) - 2\left(\pi\left(1, I\right) - \pi\left(0, I\right)\right)$ According to condition (5), net profits are smaller than $\pi\left(0, I\right)$. Hence, firm i would be better off to lower the wage offer and to have no trained workers.

---

[18]Note that Part (b) of Proposition 5 is not a full description of the turnover game. For our analysis, we do not require such a full solution which amounts to a tedious case-by-case discussion. For instance, for the case that I is even, we calculated conditions for an equilibrium where half the firms have two workers each, but the others have none. Equilibrium wages are such that all firms have identical net profits.

Hence, the constellation cannot be an equilibrium.

(b) Suppose that $\pi(2, I) - \pi(1, I) > \pi(1, I) - \pi(0, I)$. First, a symmetric training equilibrium requires that wages are at most $\pi(1, I) - \pi(0, I)$; otherwise firms could profitably deviate by reducing the wage so that they do not employ a worker. As $\pi(2, I) - \pi(1, I) > \pi(1, I) - \pi(0, I)$, with such a proposed equilibrium wage, firms could profitably deviate by offering a slightly higher wage, so as to employ a second worker. Thus, any subgame equilibrium must involve an asymmetric worker distribution. In such an equilibrium, if a firm without trained workers, say firm i has smaller net profits than other firms, it can deviate by offering slightly higher wages to the workers of firms who employ trained workers, so that these workers go to firm 1 and it earns approximately the higher net profits of other firms. ■

This proposition substantiates Observation 1. We now move to Observation 2.

Proposition 6 *Suppose that $I - 1$ firms have trained their workers and (8) holds. Then, the resulting turnover game has an equilibrium where each worker receives a maximal wage offer of $w^* = \pi(1, I - 1) - \pi(0, I - 1)$ and $(I - 1)$ firms employ exactly one worker. Accordingly, net profits for all firms are $\pi(0, I - 1)$.*

Proof. If each firm offers w^*, all firms receive net profits $\pi(0, I - 1)$. First, consider deviation incentives for firms that employ a trained worker in equilibrium. Such firms earn gross profits $\pi(1, I - 1)$, from which $\pi(1, I - 1) - \pi(0, I - 1)$ have to be deducted. Downward deviations (below w^*) for such firms would not be profitable. They would not have to pay wages, but gross profits would drop to $\pi(0, I - 1)$. By increasing wages slightly above w^*, a firm could obtain additional workers. Gross profits from hiring $t_i - 1$ workers would be $\pi(t_i, I - 1)$ rather than $\pi(1, I - 1)$. Subtracting wage payments, the net gain from deviation is thus approximately

$$\pi(t_i, I - 1) - \pi(1, I - 1) - (t_i - 1)(\pi(1, I - 1) - \pi(0, I - 1)) \leq 0.$$

By (8), this expression is non-positive. Next consider the incentives of the firm without a worker to increase its wage offer slightly. This would increase gross profits by $\pi(1, I-1) - \pi(0, I-1)$, but increase wages by approximately the same amount. More generally, increasing wage offers to any number $(t_i - 1)$ of workers is not profitable by (8). ∎

8.2   Appendix B: Gross profits

We now compile the formulas that we use for the numerical analysis:

$$\pi(0, I) = \frac{1}{b(I+1)^2}\left(a - Ic\frac{\delta}{\delta+1} + c\left(-\frac{2}{\delta+1} + \frac{1}{2\delta+1}\right)\right)^2;$$

$$\pi(1, I) = \frac{1}{b(I+1)^2}\left(a - \frac{c}{\delta+1}\right)^2;$$

$$\pi(2, I) = \frac{1}{b(I+1)^2}\left(a + Ic\left(\frac{1}{\delta+1} - \frac{1}{2\delta+1}\right) + c\frac{\delta-1}{\delta+1}\right)^2;$$

$$\pi(0, I-1) = \frac{1}{b(I+1)^2}\left(a - Ic\frac{\delta}{\delta+1} - \frac{c}{\delta+1}\right)^2;$$

$$\pi(1, I-1) = \frac{1}{b(I+1)^2}\left(a + c\left(\frac{\delta-1}{\delta+1}\right)\right)^2;$$

$$\pi(2, I-1) = \frac{1}{b(I+1)^2}\left(a + Ic\left(\frac{1}{\delta+1} - \frac{1}{2\delta+1}\right) + c\frac{2\delta-1}{\delta+1}\right)^2.$$

Defining $c_j = 0$, the Payoffs that were used in the calculations in Section 5 are

$$\tilde{\pi}(1, I) = \frac{1}{b(I+1)^2}\left(a + \frac{\delta c}{\delta+1} + I\left(\frac{\delta c}{\delta+1} - \varepsilon\right)\right)^2,$$

$$\tilde{\pi}(2, I) = \frac{1}{b(I+1)^2}\left(a + Ic\left(\frac{1}{\delta+1} - \frac{1}{2\delta+1}\right) + 2c\frac{\delta}{\delta+1} + I\left(c\frac{2\delta}{2\delta+1} - \varepsilon\right)\right)^2,$$

$$\tilde{\pi}(0, I-1) = \frac{1}{b(I+1)^2}\left(a - I\left(c\frac{\delta}{\delta+1} + \varepsilon\right) + c\frac{\delta}{\delta+1}\right)^2.$$

8.3 Appendix C: Welfare effects of Integration

8.3.1 Proof of Proposition 1

Proof. (i) If there is a training equilibrium before and after integration, welfare increases if and only if $P_{2I}(T) < P_I(T)$, as $W_{2I}^T > W_I^T$ reduces to a simple comparison of the sum of gross producer and consumer surplus before and after integration. From (3),

$$p_I(T) = \frac{a}{I+1} + \frac{Ic}{(I+1)(\delta+1)}. \tag{10}$$

Thus, $P_{2I}(T) < P_I(T)$ is obvious. The proof for the equilibrium without training is analogous.

(ii) Calculating wages $w^*(I)$ as a function of I yields

$$
\begin{aligned}
w^*(I) &= \pi(2,I) - \pi(1,I) \\
&= \frac{1}{b(I+1)^2}\left[\left(a + Ic\frac{\delta}{(2\delta+1)(\delta+1)} - c\frac{1-\delta}{\delta+1}\right)^2 - \left(a - \frac{c}{\delta+1}\right)^2\right].
\end{aligned}
$$

For sufficiently large values of I, $\partial w^*/\partial I > 0$. Therefore $w^*(I) < w^*(2I)$ if I is sufficiently large.

(iii) follows immediately from taking the derivative of $\pi(1,I) = \frac{1}{b(I+1)^2}\left(a - \frac{c}{\delta+1}\right)^2$ with respect to I, which is

$$-\frac{2}{(\delta+1)^2(I+1)^3}(10\delta+9)^2 < 0.$$

∎

8.3.2 Proof of Proposition 3

(i) Recall formula (10) for $p_I(T)$, and

$$p_{2I}(0) = \frac{a}{2I+1} + \frac{2Ic}{2I+1}.$$

Simple rearrangements show that $p_{2I}(0) < p_I(T)$, if $a < A^*$.

$$a > A^* \equiv \frac{c}{1+\delta}\left(1 + 2\delta(I+1)\right)$$

(ii) follows from (i) since integration reduces prices and training costs.

9 References

Acemoglu, D., and J.S. Pischke (1998), "Why Do Firms Train? Theory and Evidence", *Quarterly Journal of Economics*, 113 (1), 79-119.

Acemoglu, D. and Pischke, J.S. (1999), "Beyond Becker: Training in Imperfect Labour Markets" *Economic Journal 109, F112-F142.*

Cartiglia, F. "Credit Constraints and Human Capital Accumulation in the Open Economy", *Journal of International Economics, (1997)* Vol. 43, 221-36

Chuang, Y.C. "Learning by Doing, Technology Gap and Growth", *International Economic Review,* 39, 697-722 (1998).

Clark, D., and R. Fahr (2001), "The Promise of Workplace Training for Non-College-Bound Youth: Theory and Evidence from German Apprenticeship", *IZA Discussion Paper*, No. 378.

Die Welt, July 30, 2005, "Wirtschaft fordert Absenkung der Lehrlingsgehälter."

Euwals, R. and R. Winkelmann (2001), "Why Do Firms Train? Empirical Evidence on the First Labour Market Outcomes of Graduated Apprentices", *IZA Discussion Paper* No. 319.

Feenstra, R., Hanson, G. "Global Production Sharing and Rising Inequality: A Survey of Trade and Wages", (2001), *NBER Working Paper No. 8372.*

Findlay, R. and H. Kierzkowski (1983), "International Trade and Human Capital: A Simple General Equilibrium Model", *Journal of Political Economy* 91, 957-978.

Franz, W. and Soskice, D. "The German Apprenticeship System" in F. Buttler et al.: *Institutional Frameworks and Labor Market Performance. Comparative Views on the German and U.S. Economies,* London, Routledge, 208-234 (1995).

Gersbach, H. and Schmutzler, A. "A Product Market Theory of Training and Turnover in Firms", *CEPR Discussion Paper No. 3940* (2003).

Gersbach, H. and Schmutzler, A. "Globalization and Worker Training", *CEPR Discussion Paper No. 4879* (2004).

Harhoff, D., and T.J. Kane (1997), "Is the German Apprenticeship System a

Panacea for the US Labour Market?", *Journal of Population Economics* 10, 171-196.

Kim, S., Kim, Y. "Growth Gains from Trade and Education", *Journal of International Economics,* (2000), Vol. 50, 519-45.

Rodrik, D. "Has Globalization Gone Too Far?", (1997), Institute for International Economics.

Ryan, P. (2001), "The School-to-Work Transition: A Cross-National Perspective", *Journal of Economic Literature*, 39 (1), 34-92.

Stokey, N. (1991) "Human Capital, Product Quality, and Growth", *Quarterly Journal of Economics* 106, 587-616.

Wood, A. and C. Ridao-Cano (1999) "Skill, Trade and International Inequality", Oxford Economic Papers, 51, pp. 89-119.