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Working Paper

Globalization and general worker training

Working Paper, No. 0403

Provided in Cooperation with:

Socioeconomic Institute (SOI), University of Zurich

Suggested Citation: Gersbach, Hans; Schmutzler, Armin (2004) : Globalization and general worker training, Working Paper, No. 0403, University of Zurich, Socioeconomic Institute, Zurich

This Version is available at:

<https://hdl.handle.net/10419/76212>

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Socioeconomic Institute
Sozialökonomisches Institut

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Publisher

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Rämistrasse 71
CH-8006 Zürich
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Globalization and General Worker Training

Hans Gersbach* and Armin Schmutzler**

This Version: February 13, 2004

ABSTRACT: We examine how globalization affects firms incentives to train workers. In our model, firms invest in productivity-enhancing worker training before Cournot competition takes place. When two separated *product markets* become integrated and are thus replaced with a market with greater demand and greater firm number, training by each firm increases provided the two countries are sufficiently small. When barriers between large markets are eliminated, training is reduced. Similar results hold when firms in countries with different training systems face globalization of product markets. In particular, apprenticeship systems are threatened by a large-scale integration of product markets. Contrary to product market integration, *labor market integration* has no effect on training incentives.

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

JEL: D42, L22, L43, L92.

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We are grateful to Alexandrina Braack and Verena Liessem for their helpful comments.

1 Introduction

There are compelling reasons why globalization should affect human capital accumulation. The relevant research typically refers to workers' incentives to acquire human capital: Globalization affects both the returns to education and its costs. With respect to costs, there are two influence channels (Carriglia 1997). First, because trade has income effects, it changes the liquidity constraints that workers are facing, and thus their ability to invest into education. Second, by increasing the relative wages of skilled workers, trade openness also increases the costs of education.

However, economic integration not only affects the costs from education, but also the returns. For instance, globalization appears to raise the difference between skilled and unskilled wages (Feenstra and Hanson 2001). Other things being equal, this would suggest that globalization increases the return from education. On the other hand, there may be countervailing forces, relating particularly to sector-specific human capital investments. Rodrik (1997) argues that uncertainty about sector-specific shocks brought about by globalization may reduce the incentives to acquire sector-specific skills, unless adequate insurance mechanisms are present. Thus, globalization should lead to a shift from sector-specific to general human capital investment (Kim and Kim, 2000).

All of these studies concentrate on *workers'* incentives to acquire human capital. It is well known, however, that a considerable part of education and training is financed by *firms*. This is not only true for firm-specific human capital, but also for sector-specific or even general human capital.¹ This paper investigates how globalization affects firms' incentives to invest in general human capital. We start from the fundamental puzzle that Becker (1964) and Mincer (1974) have identified: At least in competitive labor markets, firms should have no incentive to bear the costs of general worker training, as the associated rents are captured by the employees. Recent theoretical work has

¹See e.g. Baily and Gersbach (1995), Blundell et al. (1996), Goux and Marin (1997), Loewenstein and Spletzer (1998), Regner (1995, 1997) and Vilhuber (1997,1998).

presented arguments that resolve the puzzle, many of which rely on asymmetric information.²

In the following, we analyze the effects of globalization on worker training. To this end, we use an alternative resolution of the general training puzzle, which relies on Gersbach and Schmutzler (2003). There, we argue that the extent of worker training and the intensity of competition on product markets are closely related: Broadly speaking, less intensive competition fosters training incentives. The relevance of these ideas for international product market integration is obvious: the increase in firm numbers that is brought about by the integration of markets is an instance of more intense competition. Other things being equal, product market integration should therefore make general worker training less likely. However, this cannot be the full story, as integration also increases market demand. This, in itself, increases incentives for training. In the paper, we show how these effects interact.

We analyze two cases, the immobile worker model and the mobile worker model. In both cases, we consider two initially separated national product markets, each of which is a Cournot oligopoly. Product market competition is preceded by a training stage in which each firm can decide whether to train its workers or not. Firms whose workers have been trained have lower marginal production costs than those without trained workers, as workers are more productive. In both cases, we consider the effects of market integration: An integrated market is described by the same model, except that the firm number and the market demand are both twice as high as before.

In the *immobile worker model*, workers are prohibited to move both within and between countries, so that the Becker-Mincer puzzle is defined away. The game only consists of the training stage and product market competition. In the *mobile worker model*, there is an interim stage in which firms make wage bids for each others workers. The effects of market integration on training

²Examples include Katz and Ziderman (1990), Chang and Wang (1995, 1996), Abe (1994), Prendergast (1992), Glaeser (1992), Acemoglu (1997) and Acemoglu and Pischke (1998). Acemoglu and Pischke (1999) provide an insightful survey of the arguments.

incentives are similar in both cases. First, suppose the two countries are small initially, meaning that the firm number and demand are both small. Then, integration increases incentives for training, and for suitable parameter values market integration leads to a training equilibrium where none existed before. If countries are sufficiently large initially, a training equilibrium can be destroyed by market integration. The same conclusions emerge if workers are only mobile within national borders.

In addition to product market integration, we also consider labor market integration. At first glance, when workers face more options concerning future employers, the willingness of firms to train their workers should be reduced. However, we show that, at least in our setting, labor market integration usually has no effect on training decisions.

While our main focus is on the integration of countries with the same sort of training by firms, we also apply our analysis to countries that face competition in product markets from countries that have other or no training systems. For example, countries with apprenticeship systems, such as Germany, face competition by firms headquartered either in countries with vocational schooling systems or in low-skilled countries with no or little training. We show that such competition is indeed a threat to apprenticeship systems.

There has been a thorough discussion about the slow decline of the number of apprentices in countries such as Germany³. Our analysis points to a complementary argument for this decline. Globalization makes it more difficult to sustain apprenticeship systems and without government intervention such systems are prone to decline in a globalized world.

The paper is organized as follows. Section 2 analyzes the model with immobile workers. Section 3 introduces the model with mobile workers, and provides reduced form conditions for training equilibria. Section 4 applies these conditions to a numerical example. Section 5 analyzes how globalization, that is labor and/or product market integration affects the chances that training equilibria arise. Section 6 extends the analysis to countries with

³See e.g. Euwals and Winkelmann 2001, Franz and Soskice 1995, Büchel 2002.

asymmetric training systems. Section 7 concludes and discusses extensions.

2 The Model with Immobile Workers

We shall consider different variants of training models to capture different degrees of product market integration and worker mobility.⁴ Our first model, the *Training Game with Immobile Workers*, deals with an integrated product market, and workers are immobile. It can either be interpreted as the model of one national market that is completely closed or as the model of a fully integrated world market.

The structure of the model is as follows. In period 1, firms $i = 1, \dots, I$ simultaneously choose their general human capital investment levels $g_i \in \{0, 1\}$. Thus, for simplicity, we treat training as a zero-one decision. 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, i.e., education is only valuable if the entire team is educated.⁵ The effect of training is to reduce marginal costs c_i , which are assumed to be functions $c(g_i)$ of the number of trained workers in a firm. Training costs $T > 0$ for a firm.

In period 2, the I firms are Cournot competitors, producing homogeneous goods, with inverse demand $p = a - \frac{B}{I} \cdot x$, where x is output, p is price and a and B are positive constants. Note the dual role of I here. It is not only the firm number, but also a measure of market size. This is convenient to analyze the effects of market integration: For instance, when two identical countries integrate, both the firm number and the market size double.

Recall the standard result that profits in a Cournot oligopoly with inverse

⁴Some of the results in Vives (2003) address similar issues than the ones discussed in this section.

⁵The model of this section can easily be extended to more general choices of training levels. However, such generalization is less straightforward for the model with mobile workers (Section 3). To allow for a comparison of both models, we restrict ourselves to the 0-1 case.

demand $p = a - b \cdot x$ ($b > 0$) and marginal costs (c_1, \dots, c_I) are

$$\pi_i = \frac{1}{b(I+1)^2} \left(a - Ic_i + \sum_{j \neq i} c_j \right)^2. \quad (1)$$

To illustrate our results, we use the specific training technology

$$c(g_i) = \frac{c}{\delta g_i + 1} \text{ for some } \delta > 0, g_i \in \{0, 1\}. \quad (2)$$

Using (1) and (2), profits of firm i in this case are:

$$\pi_i(g_i, G) = \frac{I}{B(I+1)^2} \left(a - \frac{cI}{\delta g_i + 1} - \frac{(G - g_i)c}{\delta + 1} + (I - 1 - G + g_i)c \right) \quad (3)$$

where G is the total number of firms, who train their workers.

In this set-up, we give conditions for a symmetric *training equilibrium* where all firms train one worker, that is, $g_i = 1, i = 1, \dots, I$. To this end, the following notation is helpful:

$$\Delta\pi \equiv \pi_i(1, I) - \pi_i(0, I - 1).$$

Thus $\Delta\pi$ describes the *training incentives* for a firm when all its competitors also train their workers. Also, we use the notation $\alpha = a - c$.

Proposition 1 *When workers are immobile, a training equilibrium in an industry with n firms exists if and only if*

$$\Delta\pi = \pi_i(1, I) - \pi_i(0, I - 1) \geq T.$$

Proof. By symmetry, it suffices to consider the equilibrium condition for firm 1. Clearly, an equilibrium with training exists if and only if $\Delta\pi > T$. ■

Applying (3), it is straightforward to show that

$$\Delta\pi = \frac{\delta c I^2}{B(I+1)^2(1+\delta)^2} \{2\alpha(1+\delta) - (I-2)\delta c\}. \quad (4)$$

Condition (4) implies that a greater value of I has a positive effect on training if the initial value of I is sufficiently low, and a negative effect if the initial value is sufficiently high.

Corollary 1 *Suppose workers are immobile. As I increases, the range of parameters α, δ, B, c for which a training equilibrium exists first increases, then decreases.*

Proof. Simple calculations show that

$$\frac{\partial(\Delta\pi)}{\partial I} = \frac{\delta c I}{B(I+1)^3(1+\delta)^2} [\delta c(4-3I-I^2) + 4\alpha(1+\delta)],$$

which is positive if and only if

$$\delta c(4-3I-I^2) + 4\alpha(1+\delta) > 0.$$

There is a unique $I^* > 0$ for which the left-hand-side is 0. To the right of I^* , the left-hand-side is negative. ■

Figure 1 plots $\Delta\pi$ as a function of I for $a = 10$, $c = 1$, $B = 1$, $\delta = 0.9$. The figure shows how the effects of globalization on training depend on the initial number of firms in each country. If firm numbers in each country are I_k ($k = 1, 2$), the pre-integration equilibrium in country k corresponds to I_k , whereas the post-integration equilibrium in the world economy corresponds to $I_1 + I_2$. Suppose, for instance that $T = 5$. Then, if $I_1 = I_2 = 3$, there will be no training equilibrium in either country, as $\Delta\pi < T$. After product market integration, there are six firms in the market, with twice the market size of each country. Now $\Delta\pi > T$, so that the training equilibrium exists. Hence, globalization creates a training equilibrium. On the other hand, suppose each country is initially served by a relatively high number of firms, e.g. $I_1 = I_2 = 10$. Then, there is a training equilibrium before integration. After integration, the world industry is served by 20 firms, and the corresponding training incentive satisfies $\Delta\pi < T$. Thus, in this case, globalization destroys the training equilibrium.

This example illustrates a principle that occurs repeatedly in this paper: If the two countries (that is, their firm numbers and market sizes) are small, the beneficial effects of integration on training that come from greater market size dominate over the negative effects from greater competition. For greater

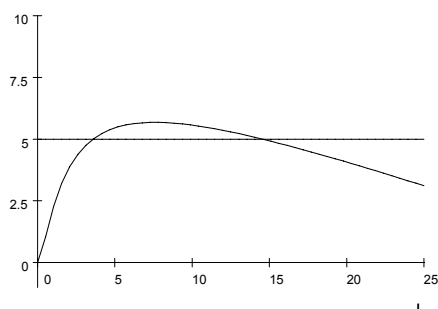


Figure 1: Training Incentives with Immobile Workers

initial country sizes, the training equilibrium is destroyed when globalization takes place.

3 Mobile Workers

In a discussion of globalization and training, worker mobility is important for two reasons. First, even when workers only move *within* countries, training behavior is likely to be affected by worker mobility, because firms have to take the possibility into account that competitors might poach trained workers. This tends to reduce training levels both before and after integration. Without further analysis, it is thus unclear how the effects of product market integration change when within-country mobility is taken into account. Second, worker mobility between countries is an aspect of globalization that is, in itself, worthy of study. How does such mobility affect training incentives? A first intuition would be that training incentives are reduced, because firms face a greater danger that competitors poach trained worker. We check whether this intuition is correct.

Before explicitly addressing the comparative statics of globalization in Sections 4 and 5, we extend our model by introducing an additional stage

between training and product market competition, taking into account the possibility that a firm now has more than one trained worker, because it poached labor from competitors. The *Training Game with Mobile Workers* is therefore defined as follows.

3.1 The Game Structure

The game involves three periods. In period 1, training takes place as before, resulting in training levels $g_i \in \{0, 1\}$. In stage 2, firms simultaneously make wage offers for each others workers. Thus, each firm $i \in \{1, \dots, I\}$ makes a list of wage offers $w_{ij}, j \in \{1, \dots, I\}$ for all of the trained workers in the market. If $g_j = 0$ wages will be $w_{ij} = 0, i = 1 \dots I$. In principle, we allow wages to differ even for individuals who have the same level of human capital or belong to the same firm.⁶ We normalize wages of non-trained workers to zero. Further, we assume that the wage of a non-trained worker 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.⁷ Denote the number of trained workers in firm i at the end of period 2 as t_i . Recall that G is the total number of trained workers in period 1, which is the same as the total number of firms that train their workers. Hence $G = \sum_{i=1}^n t_i$.

As before, having trained workers is beneficial, as it reduces marginal production costs. However, as firms can now have more than one trained worker, we need to define the cost function more generally. Modifying (2) accordingly, we assume that:

$$c(t_i) = \frac{c}{\delta t_i + 1} \text{ for some } \delta > 0. \quad (5)$$

⁶Here "wages" should be interpreted broadly, including any type of non-monetary benefits such as pleasant working environments, fringe benefits and flexible working hours which involve costs for the employer.

⁷As a tie-breaking rule, we use the convention that the employee stays in his original firm if this firm offers the highest wages. In some cases, which we will state explicitly, we deviate from this rule in order to obtain convenient equilibrium formulations.

In period 3, Cournot competition takes place. As in Section 2, the demand function is $x = \frac{I}{B}(a - p)$. Marginal costs are determined by (5).

The game structure is summarized in the Table 1. There and in the following, we distinguish between *net profits* and *gross profits*, according to whether wages for trained workers are deducted or not. Further, we define the *long-term payoff* of a firm as the difference between net profits and training expenses.

Table 1: **Game Structure**

<i>Period 1:</i>	Firms $i = 1, \dots, I$ choose training levels g_i .
<i>Period 2:</i>	(i) Firms choose wage offers $w_{i,j}(g_1, \dots, g_I)$. (ii) Workers choose between employers, thus determining the numbers t_i of trained workers.
<i>Period 3:</i>	Product market competition results in gross profits $\pi_i(t_1, \dots, t_I)$.

Gross profits depend on marginal costs, as described in (1). Using (5), gross profits can therefore be expressed as functions $\pi_i(t_1, \dots, t_I)$. Note that, as t_i can be greater than 1 if a firm poaches the workers of competitors in stage 2, the notation $\pi_i(t_i, G)$ is no longer well-defined, as it is no longer clear that they are employed by $G - t_i$ different firms, each of which has one worker. For firm i , it makes a difference how the $G - t_i$ workers employed by competitors are distributed across the other firms. We nevertheless continue to use $\pi_i(t_i, G)$, with the following additional conventions on the distribution of workers:

- (i) If $G - t_i \leq I - 1$ the notation $\pi_i(t_i, G)$ refers to the case that every competitor of firm i has at most one trained worker.
- (ii) If $G - t_i > I - 1$ or equivalently if $t_i = 0$ and $G = I$, the notation $\pi_i(t_i, G)$ refers to the case that one firm has two trained workers while all other competitors of firm i have one worker.

In order to simplify the notation further, we often neglect the index i and write $\pi(t, G)$ if this causes no confusion.

A full description of the subgame perfect equilibria of the game is complex. We restrict ourselves to providing existence conditions for a symmetric training equilibrium such that each firm trains one worker. In the rest of this section, we express equilibrium conditions in reduced form, because the parameterized conditions are not very transparent. The conditions we obtain make sense beyond the Cournot case. In Section 4, we shall show how our conditions can be understood in terms of the parameters of the Cournot example.

3.2 Turnover Equilibrium

We first consider the subgame given by $(g_1, \dots, g_I) = (1, \dots, 1)$. We provide a condition under which, starting from a situation where each firm has trained a worker in period 1, there will be no turnover in period 2, and we characterize equilibrium wages. Condition (1) implies that equilibrium gross profits are

$$\pi(1, I) = \frac{I \left(a - \frac{c}{\delta+1}\right)^2}{B(I+1)^2} = \frac{I \left(\alpha + \frac{\delta c}{\delta+1}\right)^2}{B(I+1)^2}. \quad (6)$$

Define

$$AP(t_i, I) = \frac{\pi(t_i, I) - \pi(1, I)}{t_i - 1}.$$

$AP(t_i, I)$ can be interpreted as the average productivity of each of the $t_i - 1$ workers that a firm poaches from competitors. Importantly, from a firm's point of view the positive productivity effect of poaching a worker also consists of the negative effect imposed on the competitor.

Proposition 2 *Suppose each firm has trained one worker in period 1.*

(a) *Suppose*

$$\pi(1, I) - \pi(0, I) \geq \pi(2, I) - \pi(1, I). \quad (7)$$

Further, suppose that

$$\max_{t_i \in \{2, \dots, I\}} AP(t_i, I) \leq \pi(2, I) - \pi(1, I). \quad (8)$$

Then there is an equilibrium of the turnover game where the highest wage for each worker is given by⁸

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

In any equilibrium each firm will employ exactly one trained worker.

(b) Suppose that condition (7) does not hold. Then, in any pure strategy equilibrium 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.

Proof. See Appendix ■

Intuitively, the equilibrium wage is the willingness of each firm to pay for a second worker. We shall show in Section 4 that the conditions of this proposition hold for a wide range of parameters.

Condition (7) guarantees that, starting from an equal distribution of workers, the gains from attracting a worker ($\pi(2, I) - \pi(1, I)$) are smaller than the losses if a competitor attracts a worker ($\pi(1, I) - \pi(0, I)$). Thus, each firm is willing to offer w^* , and there is no turnover.

Condition (8) makes sure that it is not a profitable deviation to attract further workers from the competitors: no matter how many workers a firm poaches, the average productivity of a worker will be below the wage, which is the "marginal productivity" of the second worker. A simple sufficient condition for (8) is that the marginal productivity $\pi(t_i, I) - \pi(t_i - 1, I)$ is declining in t_i .

To analyze firms incentives to deviate from a training equilibrium, we also need to consider the subgame where one firm does not invest into training.

Proposition 3 *Suppose that, in period 1, $I - 1$ firms have trained their workers. Suppose that, in addition,*

$$\pi(1, I - 1) - \pi(0, I - 1) \geq \pi(2, I - 1) - \pi(1, I - 1). \quad (9)$$

⁸The equilibrium is supported by wage offers $w_{ij} = w^*, i = 1, \dots, I$ and $j = 1, \dots, I$. The equilibrium can also be supported by $\{w_{ii} = w^*, w_{i,j+1} = w^*, w_{I1} = w^*, w_{II} = w^*$ for $i = 1, \dots, I - 1\}$ and zero wage offers in all other cases.

and

$$\max_{t_i \in \{2, \dots, I-1\}} AP(t_i, I-1) \leq \pi(1, I-1) - \pi(0, I-1) \quad (10)$$

Then, the resulting turnover game has an equilibrium, where each worker receives a wage offer of $w^* = \pi(1, I-1) - \pi(0, I-1)$. Accordingly, net profits for all firms are $\pi(0, I-1)$.

Proof. See Appendix 1. ■

Note that (9) is analogous to (7), but for $I-1$ instead of I . However, composed to the right hand side of (8), the right hand side of (10) is smaller. Intuitively, compared to the case that all firms have trained their workers, each worker now has greater bargaining power, because trained workers are relatively scarce: By moving to the competitor without a trained worker, product market profits of an employer could be reduced by $\pi(1, I-1) - \pi(0, I-1)$. Net profits $\pi(0, I-1)$ are smaller than what firms would have obtained without training.

Propositions 2 and 3 allow us to analyze the conditions under which a training equilibrium exist, provided the parameters are such that (7)-(10) all hold simultaneously. As we will see in a numerical example below, (8) and (10) hold for many parameter values. (7) and (9) still hold for a fairly large set of parameters, so that it is already an interesting exercise to restrict the search for training equilibria to the parameter regions where all four conditions hold.

However, it would also be interesting to extend the analysis beyond these regions, in particular, because the extent of globalization (appropriately defined) has an influence on whether conditions (7)-(10) are satisfied. Unfortunately, the analysis becomes more complex when (7) does not hold.

In Appendix 2, we provide a typical example for the turnover game when condition (7) does not hold. In equilibrium half of the firms have 2 workers, whereas the other half of firms do not employ trained workers. Equilibrium profits are the same for all firms.

A further complication arises since the tie-breaking rule that describes where workers stay in case of indifference must be modified when conditions

(7) and (9) do not hold. We use the following tie-breaking rule in this case. Firms that do not train will end up with no trained employees. The remaining distribution of trained workers is determined by equilibrium requirements. Hence, if a firm does not train, it will end up without a worker in the turnover game, no matter whether condition (9) holds or not. Thus, a firm that deviates from a training equilibrium will earn profits corresponding to the gross profit of a firm with no trained worker facing $I - 1$ workers that are, however, not necessarily distributed equally across competitors when the conditions of Proposition 3 are violated.

Usually, the profits of a firm without a trained worker should be higher, the lower the number of trained workers employed by the competitors. These considerations motivate the following assumption.

Assumption 1 *When the conditions of Propositions 2a or 3 do not hold, net profits for a firm are lower in the subgame where each firm trains one worker than in the subgame where this firm deviates to "No Training".*

The reason we have formulated this statement as an assumption rather than a result is that there is a snag in the argument just presented. Clearly, the statement will be true if, in the training case, the distribution of workers across competitors relative to the deviation case is such that one firm has an additional worker and all the others have the same number of workers. So far, however, we have not established such a result about the distribution of workers, so we have stated the condition on net profits as an assumption.

3.3 Training Equilibrium

Using Propositions 2 and 3, it is straightforward to delineate parameter regions for which an equilibrium with training exists.

Proposition 4 *Suppose (8) and (10) hold. A training equilibrium exists if*

$$2\pi(1, I) - \pi(2, I) - \pi(0, I - 1) \geq T. \quad (11)$$

Suppose that, in addition, Assumption 1 holds. Then, no training equilibrium will exist if (11) is violated.

Proof. See Appendix 1. ■

The intuition for the if-part is straightforward. Gross product market profits in a training equilibrium are $\pi(1, I)$. (11) implies (7). Thus, there is no turnover in the second stage and wages are $\pi(2, I) - \pi(1, I)$ and net profits are $2\pi(1, I) - \pi(2, I)$. Deviating to "no training" would lead to $\pi(0, I - 1)$. Thus, (11) is a sufficient condition for a training equilibrium.

The argument for the second statement is similar as long as (7) holds. When (7) is violated, Assumption 1 is required to understand why deviation from training is a profitable alternative: Essentially, the deviating firms profits are determined as if it was facing less workers trained by the competitors.

4 A Numerical Example

Much of the following analysis will rely on specific parameterizations of our Cournot model. We set $a = 10$, $b = 1$, $c = 1$. We analyze the game for three different values of δ , namely 0.1, 0.5 and 0.9. Further, we allow I to vary between 2 and 25.

For the analysis of the turnover game, we consider conditions (7)-(10). For the relevant parameters, (8) and (10) are indeed satisfied. Figure 2 deals with (7), which is equivalent to

$$\Delta MPT \equiv \pi(2, I) - \pi(1, I) - (\pi(1, I) - \pi(0, I)) \leq 0.$$

Thus, the change in the marginal productivity of training has to be non-positive for an equilibrium without training to exist. Figure 2 plots $|\Delta MPT|$ for different values of δ . The highest line corresponds to $\delta = 0.9$, the lower lines to $\delta = 0.5$ and $\delta = 0.1$, respectively.

Note that the conditions of Proposition 2 hold when the functions plotted in Figure 2 have non-negative values. Thus, for all parameters under

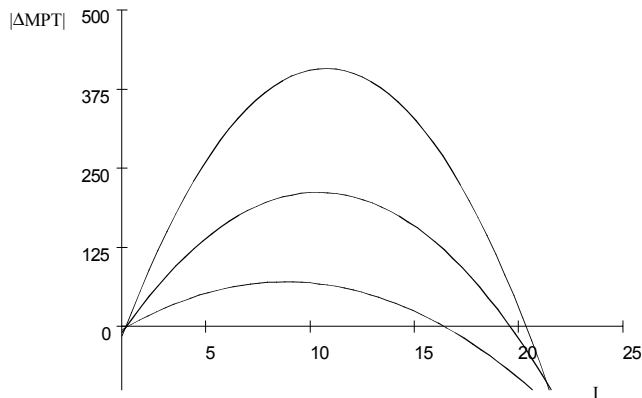


Figure 2: Turnover Game

consideration, an equilibrium without turnover exists when I is not too high. Therefore, product market integration can lead from an equilibrium without turnover to one with turnover.

Next, for each value of δ , we analyze the circumstances under which a training equilibrium exists. Recall that this can only happen for values of I below the critical levels defined by Figure 2. Assuming that parameters are such that there is no turnover in the second period, the training equilibrium exists when

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

The left-hand side can be interpreted as the net training incentive, that is, the maximal willingness to pay for training. Figure 3 depicts training incentives as a function of I for the different values of δ .

In all three cases, training incentives are first increasing, then decreasing in I . For $\delta = 0.1$ (lower curve), there is no value of I for which training incentives are positive. As δ increases, there is an intermediate range of I -values for which training incentives are positive. This region is greater for $\delta = 0.9$ than for $\delta = 0.5$.

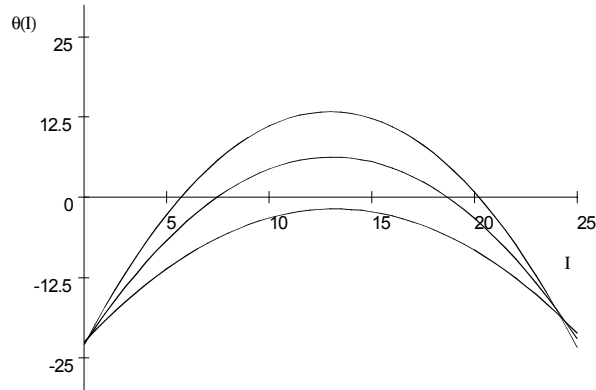


Figure 3: Training Incentives

5 The Effects of Globalization

5.1 Introduction

We now analyze the effects of labor and product market integration on training behavior. We proceed as outlined in Figure 4.

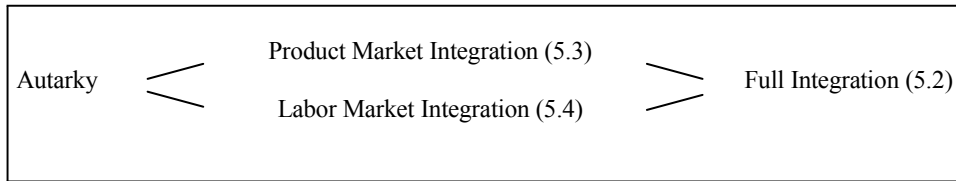


Figure 4: Types of Integration

Our reference case is *autarky*. In the autarky model, we suppose the product markets in both countries are fully separated. Labor is fully mobile within countries, but not mobile between countries. Thus, each country k ($k = 1, 2$) is described by the model of Section 3, with $I = I_k$. In Section 5.2 we shall analyze how training behavior is affected when we move from autarky to the opposite extreme, *full integration* of both product and labor markets. Again, this case corresponds to the model of Section 3, but now

with $I = I_1 + I_2$. To understand the individual contributions of both types of integration, we then move on to consider the effects of pure *product market integration* in Section 5.3: What are the effects of product market integration, when labor is only allowed to move within countries? In Section 5.4, we consider pure *labor market integration*. There, we analyze the effects of labor market integration when product markets remain separated.

5.2 Full Integration

The numerical analysis gives an idea about the effects of full integration. To understand the effects of globalization on training incentives, we have to compare net training incentives for I_1 and I_2 with those for $I_1 + I_2$. To this end, suppose the parameters are such that, qualitatively, training incentives are given as in Figure 3, that is:

- (1) Training incentives are single peaked as a function of I .
- (2) Training incentives have two intersections with the I -axis to the right of $I = 2$.

Thus, if both I_1 and I_2 are sufficiently small that $I_1 + I_2$ is still in the upward sloping part of $\theta(I)$ (or not too much further to the right), integration increases training incentives. As I_1 and I_2 increase, this is no longer true. For instance, when both values are near the maximum, net training incentives after integration will clearly be smaller than before. Thus, roughly speaking, integration has a positive effect on training if the countries are initially small and a negative effect if the countries are initially large.

Of course, the exact effect of integration on training also depends on the level of training costs. When $\theta(I_1) < T$ and $\theta(I_2) < T$, but $\theta(I_1 + I_2) > T$, integration induces training. Conversely, when $\theta(I_1) > T$ and $\theta(I_2) > T$, but $\theta(I_1 + I_2) < T$, integration destroys the training equilibrium.

The intuition for this non-monotonicity still needs to be clarified. In contrast to the immobile case, there are three effects. First, increasing market size increases the returns to training. Second, the increasing number of competitors reduces the returns to training. Third, wages $\pi(2, I) - \pi(1, I)$ for

trained workers tend to increase when I is sufficiently large.

5.3 Pure Product Market Integration

The last subsection does not spell out to which extent the effects of integration are attributable to product and labor market integration, respectively. Therefore, we now sketch how training incentives would be affected by pure product market integration, without international mobility of workers.

First, reconsider the turnover game when each firm in the global economy has trained one worker. Under conditions (7) and (8), the equilibrium described in Proposition 2 would still exist for $I = I_1 + I_2$, as long as $I_1 \geq 2$, $I_2 \geq 2$: Even though the turnover game is now only played between the firms within the country, the willingness to pay for a second worker is still $(\pi(2, I) - \pi(1, I))$, whereas the willingness to pay for the first worker is $\pi(1, I) - \pi(0, I)$. Condition (8) can even be weakened somewhat: As firms can only poach workers from national competitors, the upward deviations are limited to cases where $t_i \in \{1, 2, \dots, I_k\}$.

Similar arguments hold for Proposition 3, which concerns the turnover game when one firm has deviated from training: Intuitively, being able to move to one competitor gives the workers bargaining power vis-à-vis their employers. Adding further potential employers does not increase this bargaining power: After all, the worker can only be poached by one employer. Thus, when product markets integrate, the effects on wages are essentially independent of whether labor market integration takes place or not.

If international mobility has no effect on the turnover equilibrium, it has no effect on net wages and thus on training incentives either. Thus, somewhat surprisingly, starting from autarky, pure product market integration has the same effects on training as full integration. In other words, international labor market integration has no effect on training incentives.

Of course, the argument relies on our assumption that trained labor is homogeneous and firms therefore do not differ with respect to the type of labor they require. Without this assumption, international labor mobility

should increase the chances for workers to find a suitable employer, and therefore the bargaining power.

5.4 Pure Labor Market Integration

The last subsection showed that labor market integration has no additional effects on training if product market integration also takes place. Of course, it is still possible that labor market integration affects training decisions when there is no product market integration. However, similar arguments as in 5.3 show that labor market integration has no effect as long as there are at least two firms in each markets: Equilibrium wages in the case that all firms in country k train are given by the net effect that a second worker would have on profits, which is $\pi(2, I_k) - \pi(1, I_k)$. The argument for the deviation game is analogous, so that the training equilibrium exists when $2\pi(1, I_k) - \pi(2, I_k) - \pi(0, I_k - 1) \geq T$, just as in the autarky case.

6 Different Training Systems

6.1 The Model

Until now we have considered the impact of globalization when firms in both countries have access to the same training technologies. Countries differ, however, in this respect (see e.g Ryan 2001). Hence, it is of particular interest how particular training systems will fare in a more globalized world. Our focus will be on apprenticeship systems of the German type that have become the focus of much recent literature⁹. This literature largely concludes that firms are willing to pay a share of the training costs, although the qualifications apprentices obtain are predominantly general skills.

⁹See Franz and Soskice 1995, Oulton and Steedman 1994, Harhoff and Kane 1997, Acemoglu and Pischke 1998, Euwals and Winkelmann 2001, Büchel 2002, Clark and Fahr 2001

We now provide a stylized model showing how the integration of countries with different training systems might affect incentives of firms to invest in general training of employees. For this purpose we suppose country 1 has an apprenticeship system where $I_1 \geq 2$ firms train their workers as described in Sections 3 and 4, whereas, in country 2, firms use workers whose training is publicly funded. Formally, we simply suppose that in country 2 there are I_2 firms with marginal costs of $c - \varepsilon$, $\varepsilon \geq 0$.¹⁰

We assume that labor is mobile only within national borders. Hence, as an immediate consequence of Proposition 4 we have:

Corollary 2 *Suppose that (8) and (10) hold. Before globalization a training equilibrium in country 1 exists if*

$$2\pi(1, I_1) - \pi(2, I_1) - \pi(0, I_1 - 1) \geq T$$

Suppose now that the firms from countries 1 and 2 compete in a global market place. Profits of firms in country 1 are described by the notation $\tilde{\pi}_i(t_i, G)$ with the same conventions as in Section 3.1. $\tilde{\pi}_i(t_i, G)$ is the profit of a firm i if it has t_i trained workers, and $G - t_i$ trained workers are employed by competitors.¹¹

Hence, we obtain:

Proposition 5 *A training equilibrium in the model with different training systems exists if and only if*

$$2\tilde{\pi}(1, I_1) - \tilde{\pi}(2, I_1) - \tilde{\pi}(0, I_1 - 1) > T.$$

In the following we examine how training incentives in country 1 are affected by changes in I_2 , where $I_2 = 0$ represents the autarky case. For that purpose we concentrate on the specific cost function $c(t_i) = \frac{c}{\delta t_i + 1}$ for some $\delta > 0$.

¹⁰Hence, ε is the net cost effect which incorporates the productivity effect of trained workers and associated wage costs. When firms have to pay taxes to finance public vocational schools, such tax effects would have to be included as well.

¹¹Obviously, $\tilde{\pi}_i(t_i, G)$ also depends on I_2 ; but we suppress this variable.

6.2 Example

We now present some simple illustrations for the effects of international competition between training systems.¹² We distinguish two cases. In the first case, country 1 faces competition by firms in country 2 that have trained workers, i.e. $c_i = \frac{1}{\delta+1}$ or equivalently, $\varepsilon = c \frac{\delta}{\delta+1}$. In the second case, country 2 has only low-skilled workers, i.e. $\varepsilon = 0$. For all figures we choose $\alpha = 9$, $b = 1$ and $c = 1$.

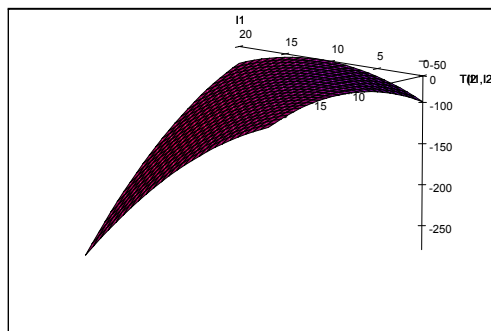


Figure 5: Systems Competition, $\delta = 0.9$

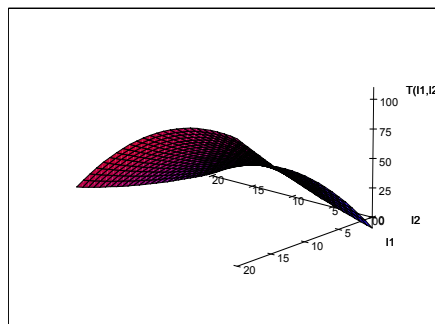


Figure 6: Low-Skill Competition, $\delta = 0.9$

¹²In Appendix 8.3, we list all relevant payoff functions.

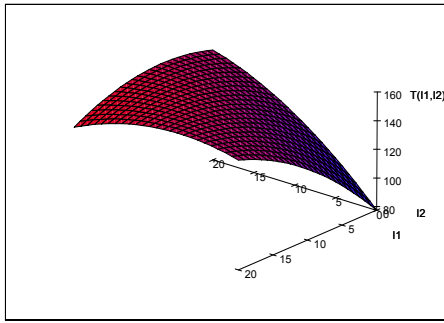


Figure 7: Systems Competition, $\delta = 0.5$

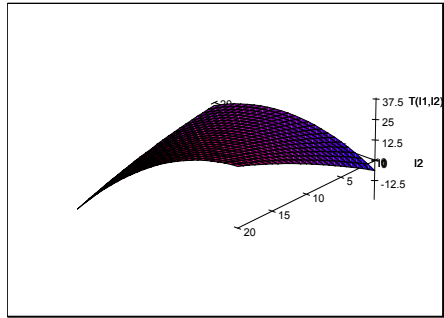


Figure 8: Low-Skill Competition, $\delta = 0.5$

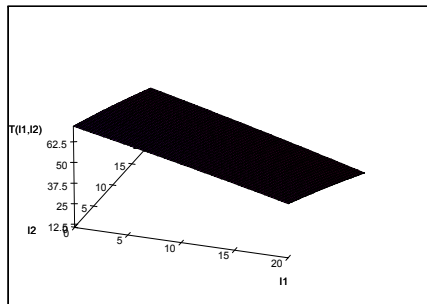


Figure 9: Systems Competition, $\delta = 0.1$

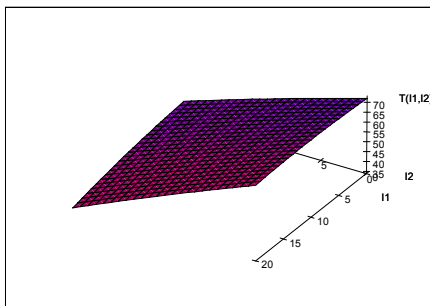


Figure 10: Low-Skill Competition, $\delta = 0.1$

Figures 5, 7 and 9 show training incentives as functions of I_1 and I_2 for different values of δ ($\delta = 0.9, \delta = 0.5$ and $\delta = 0.1$) in the case of publicly funded training. Similarly, Figures 6, 8 and 10 give training incentives for competition from low skill countries. By and large, the figures echo the common theme of this paper. Globalization on a small scale, i.e., for sufficiently small I_2 , may increase incentives to train. For larger values of I_2 , product market integration unambiguously lowers benefits from training.¹³ However, the examples suggest that the positive effects of globalization for small values of I_2 are less pronounced and even disappear in many cases. Hence, systems competition may be an even larger threat to apprenticeship systems than the integrations of product markets where all firms are subject to the same training technologies.

The preceding discussion provides a possible explanation of the decline in the number of apprentices over the last decade in Germany. Euwals and Winkelmann (2001) explain this decline with demographic and compositional factors. Our theoretical analysis suggests that globalization might have accelerated the decline of the apprenticeship system. With such forces undermining the sustainability of the system, education policy faces the difficult decision whether incentives to stabilize the system should be increased.

¹³(see for instance the examples with $\delta = 0.5$ for these patterns)

7 Conclusions and Extensions

Our paper makes two main points. First, the effects of product market integration on training incentives are positive when the initial country sizes are small and negative when country sizes are large. Second, if trained labor is homogeneous, labor market integration has essentially no effects on training.

As yet, our approach uses several simplifying assumptions. For instance, we have treated training as a zero-one decision. It is perceivable that a continuous treatment of training levels would lead to qualitative changes of the results, even in the immobile worker case.

Another simplification concerns the exogeneity of firm entry decisions. In our approach, integration does not affect the total number of firms in the market: The number of firms in the integrated market is simply the sum of firms in each market. Alternatively, one could consider a setting where the firm number is endogenous and firms might enter or exit as integration takes place. Vives (2003) considers this possibility for a situation resembling our case of immobile workers. It would be desirable to integrate his approach with the case of mobile workers discussed in Section 3.

8 Appendices

8.1 Appendix 1: Proofs

8.1.1 Proof of Proposition 2

First, we show that, if (7) 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 condition (7), the gross profit reduction from having no trained worker rather than one outweighs the reduction in wage payments w^* , so that reducing the wage offer is not a profitable deviation. Conversely, to attract more trained workers, one has to offer them wages slightly above w^* . A firm that attempts to get $t_i - 1$ additional workers, will obtain gross profits $\pi_i(t_i, I)$, but it will have to pay wages of $\pi_i(2, I) - \pi_i(1, I)$ per worker. The relevant non-deviation condition is thus

$$\pi_i(t_i, I) - \pi_i(1, I) \leq (t_i - 1) [\pi_i(2, I) - \pi_i(1, I)] \text{ for all } t_i \geq 2. \quad (12)$$

Clearly, (8) and (12) are equivalent.

Next, suppose in equilibrium workers are not distributed equally. Then, one firm (say firm 1) has at least two workers, whereas some other firms have none. By conditions (7) and (8), firm 1 is willing to pay at most $\pi_i(1, I) - \pi_i(0, I)$ on average for each of its workers. As the firms from which firm 1 has poached the workers would also be willing to pay that quantity to retain their workers, the amount does not suffice to poach the workers.

(b) Suppose that condition (7) does not hold, i.e.,

$$\pi(2, I) - \pi(1, I) > \pi(1, I) - \pi(0, I).$$

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. By condition (7), 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 distribution of workers across firms.

Now suppose that in equilibrium two firms i, j have different net profits. This requires that both firms have different numbers of workers, $t_i \neq t_j$. Assume w.l.o.g. that $t_i < t_j$. If firm i has smaller net profits, it can deviate by offering slightly higher wages to $(t_j - t_i)$ workers of firm j , so that workers go to firm i and it approximately earns the higher net profits of firm j . Note that no other firm offers the same wages in the candidate equilibrium since otherwise workers would not stay at firm j .

8.1.2 Proof of Proposition 3

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, that is, firms with gross profits $\pi(1, I - 1)$ who pay wages $\pi(1, I - 1) - \pi(0, I - 1)$. 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

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

By (10), this expression is negative. 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 the same amount. More generally, increasing wage offers to any number $(t_i - 1)$ of workers is not profitable by (10).

8.1.3 Proof of Proposition 4

Again, we consider only firm 1. Clearly, $\pi(0, I - 1) > \pi(0, I)$. Thus, if condition (11) holds, so does (7). Thus, by Proposition 2, if each firm trains

a worker in period 1, there will be no turnover in period 2, and wages are given by $\pi(2, I) - \pi(1, I)$. As gross profits in the proposed training equilibrium are $\pi(1, I)$, long-term payoffs are

$$2\pi(1, I) - \pi(2, I) - T. \quad (13)$$

If firm 1 deviates to "no training", proposition 3 implies that its long term payoff becomes

$$\pi(0, I - 1). \quad (14)$$

It remains to show that there is no training equilibrium if (11) does not hold. First suppose (7) holds. Then, there is a turnover equilibrium in the second stage, and analogous arguments as above show there is no training equilibrium. Now suppose (7) does not hold. Then, by Assumption 1, by deviating to "no training" a firm earns higher net profits than before training. In addition, it saves training costs. Thus, the deviation must be profitable.

8.2 Appendix 2: The Turnover Game without (6)

We now describe a typical equilibrium configuration when condition (7) does not hold. We shall have to deal with situations where some firms have more than one trained worker, but others have none. Specifically, we consider the following notation.

- $s_{-i}^{2,0}$: competitors of firm i have either two or 0 trained workers from the remaining $G - t_i$ employees.
- $\hat{s}_{-i}^{2,0}$: one competitor of firm i has 1 trained worker. The remaining competitors either have two employees or none.

If there are I trained workers in the industry, of which t_i work for firm i , whereas the rest is distributed according to $s_{-i}^{2,0}$, we denote profits as $\pi_i(t_i, I, s_{-i}^{2,0})$. Similarly, we use the notation $\pi_i(t_i, I, \hat{s}_{-i}^{2,0})$.

Proposition 6 Suppose $I = 2N$, that

$$2\pi(1, I, \hat{s}_{-i}^{2,0}) - \pi(2, I, s_{-i}^{2,0}) - \pi(0, I, s_{-i}^{2,0}) < 0$$

and that

$$\max_{t_i \in \{3, \dots, I\}} \left\{ \frac{\pi(t_i, I, s_{-i}) - \pi(0, I, \hat{s}_{-i}^{2,0})}{t_i} \right\} < \frac{\pi(2, I, s_{-i}^{2,0}) - \pi(0, I, \hat{s}_{-i}^{2,0})}{2}.$$

Then, there exists an equilibrium of the turnover game with wages $w^* = \frac{\pi(2, I, s_{-i}^{2,0}) - \pi(0, I, s_{-i}^{2,0})}{2}$ where N firms have 2 workers and N firms have no workers. Equilibrium profits are identical for all firms and given by $\pi(0, I, s_{-i}^{2,0})$.

Proof. (i) It is never beneficial for a firm without a worker to hire two workers. Hence (ii) suppose a firm with no worker hires one worker by offering a slightly higher wage. The net profits are at most

$$\pi(1, I, \hat{s}_{-i}^{2,0}) - \frac{\pi(2, I, s_{-i}^{2,0}) - \pi(0, I, s_{-i}^{2,0})}{2}.$$

This is smaller than equilibrium profits $\pi(0, I, s_{-i}^{2,0})$ if

$$2\pi(1, I, \hat{s}_{-i}^{2,0}) - \pi(2, I, s_{-i}^{2,0}) - \pi(0, I, s_{-i}^{2,0}) < 0$$

which holds by assumption. Again we need to check whether firms do not want to hire more than 2 workers. This is implied by the second condition. (iii) Suppose a firm with two workers does only want to hire one worker. The same considerations as in (ii) apply. ■

8.3 Appendix 3: Competition between Training Systems

This Appendix contains the Payoffs that were used in the calculations in Section 6.

$$\begin{aligned}\tilde{\pi}_i(1, I_1) &= \left(\alpha + \frac{\delta c}{\delta + 1} + I_2 \frac{\delta c}{\delta + 1} - I_2 \varepsilon \right)^2, \\ \tilde{\pi}_i(2, I_1) &= \left(\alpha + I_1 c \left(\frac{1}{\delta + 1} - \frac{1}{2\delta + 1} \right) + 2c \frac{\delta}{\delta + 1} + I_2 c \frac{2\delta}{2\delta + 1} - I_2 \varepsilon \right)^2, \\ \tilde{\pi}_i(0, I_1 - 1) &= \left(\alpha - I_1 c \frac{\delta}{\delta + 1} + c \frac{\delta}{\delta + 1} - I_2 \varepsilon \right)^2.\end{aligned}$$

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