# Firm productivity and wages: evidence from Finnish twin data[1]

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**Abstract**

This study investigates the effects of firm productivity on employees' wages. Empirical estimations are performed using linked panel data on Finnish twins and their employers. Estimation results suggest that high productivity firms may pay higher wages but effects are heterogeneous between individuals and that labor productivity affects wages more than total factor productivity (TFP). Men's wages increase more with increases in firm productivity than women's wages. Differences between genders can be driven by occupational selection. Depending on the estimation method, one standard deviation increase in firm labor productivity results in 1.6 to 3.3 percent increase in men's wages. One standard deviation increase in TFP increases men's wages by 1.0 to 2.1 percent. For women these magnitudes range between -2.5 and 2.3 percent for labor productivity and between -0.7 and 1.5 percent for TFP. The lower bounds for women are not statistically significant. Selection by ability or unobserved firm heterogeneity do not fully explain positive relationship between firm productivity and wages.

**Keywords:** *firm productivity, wages, twin data*

**JEL codes:** J31, D22

## 1 Introduction

The role of firms in wage setting is one of the key questions in economics. Competitive theories argue that worker type dictates the wage and firms act as price-takers, whereas in monopsonistic models firm specific characteristics, such as firm profitability and productivity, play a role when decisions on employees' wages are made (Manning 2003). Under certain conditions also bargaining and efficiency wage models predict a positive relationship between firm productivity and wages. There exists a large empirical literature that studies the relationship between firm profitability and wages. These studies have

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often found that more profitable firms pay their employees higher wages[3] and they have interpreted positive correlation between firm profitability and wages as evidence of frictions in labor markets (e.g. Arai 2003, Blanchflower, Oswald & Sanfey 1996, Hildreth & Oswald 1997). However, less is known on relationship between firm productivity and wages. Thus, this study focuses on firm productivity instead of firm profitability. Firm productivity is known to be persistent (Foster, Haltiwanger & Syverson 2008), whereas firm profitability may vary widely in time. Thus, firm productivity reflects more fundamental features, such as differences in technology adoption (Caselli 1999) or composition of workforce (Kremer & Maskin 1996) that make some firms more efficient than others and can drive more persistent wage differences between firms than transitory earnings shocks created by firm profitability.

Firms and employees are widely heterogeneous. Firms differ with respect to skill composition of their employees, in quality of management and in rates of technology adoption. In addition, productivity is very heterogeneous even in narrowly defined industries (see e.g. Syverson 2011). Employees on the other hand differ in their abilities, personality traits and preferences. Most of these factors are unobserved or hard to measure but they still affect the outcomes for firms and individual employees. Van Reenen (2011) concludes that improved management quality boosts productivity and finds evidence of more able individuals selecting into more productive firms. Heckman, Stixrud and Urzua (2006) and Cawley, Heckman and Vytlacil (2001) find that cognitive and noncognitive abilities affect not only labor market outcomes but also other life outcomes, e.g. teenage pregnancy and substance abuse. Ability is determined early in life and persists through life, thus creating permanent differences between individuals. Previous studies have tackled unobserved heterogeneities with fixed effects (FE) (e.g. Abowd, Kramarz & Margolis 1999, Arai 2003) or instrumental variables regressions (e.g. Van Reenen 1996, Margolis & Salvanes 2001). Unobserved individual ability has often been proxied with IQ (e.g. Bound, Griliches & Hall 1986, Blackburn & Neumark 1992) and other test scores measuring cognitive abilities (Heckman et al. 2006).

This study utilizes a rich linked data on Finnish twins and their employers. Twin data allow for different estimation strategies than in the majority of previous literature. Access to data on identical twins gives an opportunity to control for unobserved individual heterogeneity by utilizing cross sectional within twin pair (WT) variation instead of test scores or dynamic variation used in FE or first differences (FD) estimation (Ashenfelter & Kruger 1994, Isacsson 2007, Kohler, Behrman & Schnittker 2010). To my knowledge this is the first study in economics using twin data to examine this type of question.[4] Unobserved firm heterogeneity provides an additional challenge, which makes the choice of optimal

[3] Studies that find a positive relationship between firm profitability and wages include Arai (2003), Blanchflower, Oswald and Sanfey (1996), Van Reenen (1996), Hildreth and Oswald (1997), Bronars and Famulari (2001), Fakhfakh and FitzRoy (2004), Arai and Heyman (2001), Margolis and Salvanes (2001), Laine (2007) and Piekkola and Kauhanen (2003).

[4] Previously twin data has been utilized in economics to study e.g. returns to schooling (e.g. Ashenfelter & Kruger 1994; Miller, Mulvey & Martin 1995, 1997; Ashenfelter & Rouse 1998; Isacsson 1999), effects of schooling on fertility decisions (Kohler, Behrman & Schnittker 2010) and earnings effects of marriage (Isacsson 2007).

estimation method more complex. Assumptions imposed on the estimation sample and the structure of the error term play a key role in identification and thus several approaches in tackling unobserved firm heterogeneity are used.

Depending on the estimation method, one standard deviation increase in firm labor productivity results in 1.6 to 3.3 percent increase in men's wages. One standard deviation increase in total factor productivity (TFP) increases men's wages by 1.0 to 2.1 percent. For women these magnitudes range between -2.5 and 2.3 percent for labor productivity and between -0.7 and 1.5 percent for TFP with the lower bounds being statistically insignificant. The highest values of productivity coefficient are obtained from OLS regressions when unobserved individual and/or firm heterogeneity are not controlled for. Men's wages and firm productivity are positively correlated even after unobserved individual and firm heterogeneity are controlled for, whereas for women the relationship between wages and firm productivity often becomes statistically insignificant after unobserved heterogeneity is controlled for. Productivity effects on wages are stronger when productivity is measured with labor productivity than with TFP.

Our results accord with monopsonistic models (Manning 2003) in that firm productivity affects wages it pays positively. Similar heterogeneity between genders in rent sharing context has been previously observed by Nekby (2003) with Swedish data. Differences between genders may be explained by men and women selecting into different industries, firms and occupations. In the data men are working in firms where large share of employees are men, whereas the opposite holds for women. Men are more likely to work in manufacturing industries, where labor productivity can be more easily observed, costs of shirking higher are possibly higher and the main bargaining goal of labor unions is wage instead of employment. Such factors could at least partly explain why wages and firm productivity are more strongly correlated for men than for women. Theoretically these findings can be explained with bargaining and efficiency wage models.

This study supports the notion that more able individuals sort into more productive firms. After unobserved individual effects are controlled for, values for productivity coefficient drop. However, selection by ability does not fully explain the positive correlation between firm productivity and wages. The majority of results imply that unobserved firm heterogeneity is positively correlated with firm productivity and wages. If unobserved firm heterogeneity is interpreted as management quality as in Van Reenen (2011) this means that high quality managers work in high productivity firms and pay employees higher wages.

Compared to the results obtained in previous studies, the effects of firm productivity on wages appear smaller than the effects of firm profitability. This can reflect the different ways that firm profitability and firm productivity affect wages. High productivity firms pay their workers persistently higher wages, whereas high profitability may create transitory shocks in employees' wages in form of bonuses or other performance based payments. The differences in results between studies can, however, stem e.g. from different datasets, timing, institutions and other factors, so any strong conclusions are avoided.

This study is organized as follows. Section 2 discusses previous theoretical and empirical literature. In section 3 empirical modeling strategy is discussed. Section 4 describes the data I use in estimations and gives some descriptive statistics. Estimation results are found in section 5. Section 6 concludes.

# 2 Theoretical background

Several theoretical models study the role of firms in wage setting. These include competitive, rent sharing, efficiency wage and bargaining models. Models reach different conclusions on the effects of firm characteristics on wages and on the mechanisms through which these effects arise.

Standard competitive model assumes that worker type determines the wage an employee is paid that wages are set in the market and that firms take wages as given. Thus, labor supply curve is infinitely elastic and firm characteristics, such as productivity, do not affect wages. Competitive model has been adjusted to allow for short term frictions due to lags in labor supply. These lags lead to temporary inelasticities in labor supply that vanish in the longer run. Thus, more productive firms pay higher wages in the short run but in the long run these effects disappear (Hildreth & Oswald 1997).

Monopsonistic models claim that labor markets are not frictionless. Instead jobs generate rents, which mean that an unwilling separation of employer and employee makes at least one of them worse off. These models assume that employers possess some degree of market power that they can exercise in wage determination. Labor supply is no longer infinitely elastic and decisions of other firms affect labor supply for firm *p*. Workers are able to obtain some share of rents and thus, firm productivity affects wages positively (Manning 2003).

In answering the question, why wages differ across firms, efficiency wage models link involuntary employment, wages and labor productivity (Shapiro & Stiglitz 1984). Contrary to competitive models in efficiency wage models unemployment is not always voluntary. Thus, wages have a dual role of allocating labor and providing incentives for employees to exert more effort and increase labor productivity. For firms, increase in labor productivity compensates for higher wages. The model of Shapiro and Stiglitz (1984) explains why identical employees in different firms can obtain different wages. Namely, firms that find shirking particularly costly will pay higher wages in equilibrium. This means that also efficiency wage models can evoke a positive relationship between labor productivity and wages.

Bargaining models can explain why wages and firm productivity become positively correlated. In the model derived by Nickell and Wadhwani (1990) wages are jointly determined by firm’s ability to pay, strength of the union and firm's ability to retain, recruit and motivate its workforce. These factors yield a positive correlation between firm productivity and wages. The two main objectives of unions are to maximize wages and employment of their members. However, different unions emphasize these objectives differently, for example due to differences in degree of risk aversion among union members (Blair & Crawford 1984). This heterogeneity between labor unions can lead to heterogeneous relationships between wages and firm productivity.

# 3 Empirical estimation

Earnings of an employee *i* can depend on characteristics of the employee himself/herself and on characteristics of the employer. Individual and firm characteristics can be observable or unobservable. Unobserved individual characteristics include ability, personality traits and preferences. Such factors affect individual's career and employer choices and ultimately his/her earnings. Unobserved firm characteristics include e.g. manager quality and shop steward's negotiation skills, which likely affect firm productivity and wages it pays. I combine observable and unobservable individual and firm characteristics into an estimable empirical model following Andrews, Schank and Upward (2006) and obtain

$$w_{i,t} = \beta_0 + \beta_1 \varphi_{p(i,t),t} + \beta_2 X_{i,t} + \beta_3 Z_{p(i,t),t} + \theta_i + \phi_{p(i,t)} + \mu_t + \varepsilon_{i,t} \qquad (1)$$

Individuals are identified with $i = \{1,\ldots,n\}$. Time is indexed with $t = \{1990,\ldots, 2004\}$. Following the approach of Abowd, Kramarz and Margolis (1999), I denote the firm where individual *i* works in year *t* with function $p(i,t) = \{1,\ldots,p\}$. Logarithmic earnings of an individual *i* in year *t* are denoted with $w_{i,t}$. Productivity measure for firm *p(i,t)* in year *t* is denoted with $\varphi_{p(i,t),t}$. Because coefficient $\beta_1$ is the main interest of this study it is mentioned separately from other observable, potentially time varying firm factors that are included in $Z_{p(i,t),t}$. $X_{i,t}$ are observable, potentially time varying individual factors. The error term consists of four components. Unobserved individual heterogeneity, which I will denote innate ability from here on, is contained in $\theta_i$ and unobserved firm heterogeneity in $\phi_{p(i,t)}$. Both of these are assumed invariant in time. Unobserved time effects are contained in $\mu_t$. These error components may be correlated with each other and any observable variables. Standard i.i.d. error with zero mean is denoted with $\varepsilon_{i,t}$.

The presence of unobserved time effects and individual and firm heterogeneity poses certain well-known challenges for estimation of model (1). Because the time dimension of my data is relatively short, unobserved time effects $\mu_t$ will be directly estimated by using time dummies that are from here on included in $Z_{p(i,t),t}$. Unlike in some previous studies, in this study I am not interested in obtaining estimates for unobserved firm and individual heterogeneity. In controlling for innate ability two different approaches are applied: individual fixed effects (FE) and within twin-pair (WT) differencing. These approaches have different sources of identification: individual FEs use dynamic variation within individuals, whereas WT differencing uses cross-sectional variation between genetically identical twins who are assume to have similar innate abilities (Ashenfelter & Kruger 1994). Unobserved firm heterogeneity will be controlled for with three alternative but to some extent overlapping approaches. Firstly, a full set of firm dummies are included in the models, which creates a large but still manageable coefficient matrix in estimations. Secondly, to maximize the utility from FE estimation, the data is split to study firm switchers and stayers separately[5]. This division is based on model specification in equation (1) and on the assumption that unobserved firm heterogeneity is time invariant. Thirdly, differences-in-differences (DID) approach is adopted as WT differencing and first differencing (FD) are combined to differentiate out unobserved firm heterogeneity. In WT-FD estimations identification comes from changes in cross-sectional differences between years *t-1* and *t* within a pair of identical twins.

Twin data requires some modifications to general model in equation (1). Individual twins are identified using two indices, *j* and *k,* instead of *i*. Twin order within a twin pair is indexed with *j* = {1, 2}, and twin pairs are indexed with *k* = {1,…,*K*}. Because identical twins share the same genes and family background $\theta_{1,k} = \theta_{2,k} = \theta_k$ is assumed to hold. Thus, innate ability is denoted with $\theta_k$. This assumption has been criticized on the grounds that if MZ twins indeed are identical, how come they still differ with respect to certain outcomes, such as years of schooling. I argue that in the setting of this study it is feasible that identical twins end up in different firms. If an open vacancy is filled, it can be given only to one of the twins even if both of them apply. Yet, this does not rule out the possibility of idiosyncratic shocks – happy or sad accidents - that affect the abilities of identical twins differently. After implementing these notational changes, the baseline estimation equation for twin data becomes

$$w_{j,k,t} = \beta_0 + \beta_1 \varphi_{p(j,k,t),t} + \beta_2 X_{j,k,t} + \beta_3 Z_{p(j,k,t),t} + \theta_k + \phi_{p(j,k,t)} + \varepsilon_{j,k,t} \quad (2)$$

Equation (2) is estimable using pooled OLS and linked data on twins and their employers. However, such estimation strategy may easily lead to biased results for $\hat{\beta}_{1,OLS}$. If more able individuals work at more productive firms and earn higher wages, OLS results are biased upwards. Direction of bias related to unobserved firm heterogeneity can arguably be upwards or downwards. Thinking this in terms of manager quality, the former would happen if high quality managers ended up in high productivity firms and paid their employees high wages. The latter would happen if high quality managers ended up in high productivity firms but kept wages at moderate level.

[5] Firm switcher is an individual, who changes his/her employer at least once during the observation period. Stayers do not change their employer.

Many previous studies have resorted to fixed effects (FE) estimation in determining the connection between firm profitability and wages (e.g. Arai 2003). Thus, I will also estimate an individual FE model obtained from equation (2), which reads as

$$\tilde{w}_{j,k,t} = \beta_1 \tilde{\varphi}_{p(j,k,t)} + \beta_2 \tilde{X}_{j,k,t} + \beta_3 \tilde{Z}_{p(j,k,t)} + \tilde{\phi}_{p(j,k,t)} + \tilde{\varepsilon}_{j,k,t} \tag{3}$$

where $\tilde{w}_{j,k,t} = w_{j,k,t} - \bar{w}$, $\tilde{\varphi}_{p(j,k,t)} = \varphi_{p(j,k,t),t} - \bar{\varphi}$ and $\tilde{\phi}_{p(j,k,t)} = \phi_{p(j,k,t)} - \bar{\phi}$. Similar notation applies for other variables, too. Individual FE estimation differentiates out innate ability. Since $\phi_{p(j,k,t)}$ is assumed time invariant, $\tilde{\phi}_{p(j,k,t)} \neq 0$ only for those individuals, who change their employer. Thus, individual FE model will be estimated separately for firm switchers and non-switchers. The individual FE model that uses information on firm switchers will be estimated by including firm dummies in the model.

WT differencing is performed for the sample consisting only of identical twins. Cross-sectional WT differencing of equation (2) yields estimation equation (4).

$$\Delta\, w_{k,t} = \beta_1 \Delta\varphi_{p(2,k,t),p(1,k,t),t} + \beta_2 \Delta X_{k,t} + \beta_3\, \Delta Z_{p(2,k,t),p(1,k,t),t} + \Delta\phi_{p(2,k,t),p(1,k,t)} + \Delta\varepsilon_{k,t} \tag{4}$$

$\hat{\beta}_{1,WT}$ is identified if for some *k p(2,k,t) ≠ p(1,k,t)*. Like individual FE model, WT model differentiates out innate ability $\theta_k$. WT estimation does not differentiate out WT differences in unobserved firm heterogeneity $\Delta\phi_{p(2,k,t),p(1,k,t)}$. Thus, if WT differences in unobserved firm heterogeneity are correlated with WT differences in firm productivity and wages, $\hat{\beta}_{1,WT}$ is biased. To avoid this bias, firm dummies are included also in WT estimations.

As an alternative to inclusion of full set of firm dummies, I apply WT estimation jointly with first differencing (FD). After taking cross-sectional WT differences, second differencing is performed with respect to time, which makes this a DID estimator. Double differencing leads to estimation equation (5).

$$\begin{aligned}(\Delta w_{k,t} - \Delta w_{k,t-1}) &= \beta_1\big(\Delta\varphi_{p(2,k,t),p(1,k,t),t} - \Delta\varphi_{p(2,k,t-1),p(1,k,t-1),t-1}\big)\\ &+\beta_2\big(\Delta X_{k,t} - \Delta X_{k,t-1}\big) + \beta_3\big(\Delta Z_{p(2,k,t),p(1,k,t),t} - \Delta Z_{p(2,k,t-1),p(1,k,t-1),t-1}\big) + (\Delta\varepsilon_{k,t} - \Delta\varepsilon_{k,t-1})\end{aligned} \tag{5}$$

WT-FD specification given in equation (5) requires that *p(2,k,t) ≠ p(1,k,t)*, *p(2,k,t) = p(2,k,t-1)* and *p(1,k,t) = p(1,k,t-1)* hold. Thus, identification is based on those identical twin pairs who work in different firms and do not change their employer between *t-1* and *t*. This is contrary to many previous studies that have based their identification on individuals who change their employers (see e.g. Abowd et al. 1999).

# 4 Data and descriptive statistics

## 4.1. Data and definitions of key variables

Empirical part of this paper utilizes two datasets. The first data consist of Finnish twins whereas the second data contain information on total Finnish population. (TBA!! Access to total population data has not yet been granted.) Our population data are restricted to contain same birth cohorts as the twin data. This enables us to evaluate the representativeness of our twin sample and perform OLS and FE estimations for total population.

The twin sample in my disposal was originally collected with questionnaires by Department of Public Health in University of Helsinki. The sampling of twins was performed in 1974, when information on all Finnish same sex twin pairs was obtained from Population Register Centre. Questionnaire was only sent to those twin pairs where both twins were alive. The youngest cohort included in the survey was born in 1957. The questionnaire sent to twins contained questions related to basic demographic and socioeconomic variables and several life style and health related variables – such as smoking and drinking habits, height, weight and several medical conditions. Whether a twin pair was identical (i.e. monozygotic, MZ) or fraternal (i.e. dizygotic, DZ) was defined in these questionnaires using the deterministic method. It classifies twin pairs based on their answers on two questions considering their similarity in appearance during childhood.[6] It can be argued that the coverage of Finnish twin data is good – originally 11 927 twin pairs took part in the study. The first survey was conducted in 1975 and later, in 1981 and 1990, two follow up questionnaires were posted to the same twins. More information on twin survey data collection can be found for example in Kaprio et al. (1978), Kaprio et al. (1979) and Kaprio and Koskenvuo (2002).

Data used in this study contain all twins that answered to at least one of these three questionnaires. Data from twin surveys is matched to Finnish Longitudinal Employer-Employee Data (FLEED) compiled by Statistics Finland. Thus, the oldest twin cohort in the matched data is born in 1929 with the majority of the twins being born after early 1940s. Aside from the survey variables the matched twin data covers years 1990-2004 and is an unbalanced panel data of identical and fraternal twins.

The setting of this study requires that both twins of each twin pair are working in the private sector, because I can only obtain productivity measures for private sector firms. Wages are defined as natural logarithmic yearly earnings, which includes salary income and income from entrepreneurial activities. I analyze firm labor productivity and firm TFP that are obtained from ready calculated

[6] For a subsample of twins the classification to MZ and DZ twins was redone by using 11 blood markers to determine zygosity. Results of classification agreed completely as the probability of misclassification of a blood marker concordant pair was 1.7 percent.

productivity indices of Statistics Finland.[7] To avoid the problems with comparing productivity measures of firms from different industries, relative productivity measures have been constructed. Relative firm productivity is defined as $\varphi_{p(j,k,t),t}$ = ln(productivity of firm *p* in year *t*/average productivity of 2-digit industry in year *t*). Thus, the estimation results are elasticities of wages with respect to relative firm productivity.

## 4.2. Descriptive statistics

To get a first look at the connections between wages and firm productivity, table 1 comprises information on average wages in different quartiles of relative productivity distributions. In addition to reporting average wages and their standard deviations in different quartiles, t-tests are performed to see, whether average wages differ statistically significantly between productivity quartiles. Descriptive statistics are presented separately for full twin sample and sample of identical twins. In addition men and women are studied together and separately.

**Table 1. Wages and productivity distribution**

**Panel A. Full twin sample**

| | | **Relative firm LP** | | | | **Relative firm TFP** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| **Both** | **ln(wage)** | | | | | | | | |
| | Average | 10.02 | 10.10 | 10.18 | 10.31 | 10.07 | 10.11 | 10.17 | 10.27 |
| | Std. dev. | 0.460 | 0.418 | 0.422 | 0.445 | 0.463 | 0.426 | 0.421 | 0.460 |
| | **t-tests ($H_0$)** | q2 = q1 | q3 = q2 | q4 = q3 | | q2 = q1 | q3 = q2 | q4 = q3 | |
| | p-values | **< 0.001** | **< 0.001** | **< 0.001** | | **< 0.001** | **< 0.001** | **< 0.001** | |
| | | **Relative firm LP** | | | | **Relative firm TFP** | | | |
| | | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| **Men** | **ln(wage)** | | | | | | | | |
| | Average | 10.18 | 10.24 | 10.32 | 10.45 | 10.22 | 10.25 | 10.31 | 10.41 |
| | Std. dev. | 0.440 | 0.383 | 0.401 | 0.414 | 0.440 | 0.407 | 0.391 | 0.428 |
| | **t-tests ($H_0$)** | q2 = q1 | q3 = q2 | q4 = q3 | | q2 = q1 | q3 = q2 | q4 = q3 | |
| | p-values | **< 0.001** | **< 0.001** | **< 0.001** | | **< 0.001** | **< 0.001** | **< 0.001** | |
| | | **Relative firm LP** | | | | **Relative firm TFP** | | | |
| | | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| **Women** | **ln(wage)** | | | | | | | | |
| | Average | 9.83 | 9.87 | 9.95 | 10.06 | 9.86 | 9.89 | 9.94 | 10.02 |
| | Std. dev. | 0.416 | 0.374 | 0.345 | 0.396 | 0.404 | 0.362 | 0.369 | 0.410 |
| | **t-tests ($H_0$)** | q2 = q1 | q3 = q2 | q4 = q3 | | q2 = q1 | q3 = q2 | q4 = q3 | |
| | p-values | **< 0.001** | **< 0.001** | **< 0.001** | | **< 0.001** | **< 0.001** | **< 0.001** | |

Notes: Both = men and women included, ln(wage) = ln(salary income + income from entrepreneurial activities). LP = labor productivity, TFP = total factor productivity. Relative firm productivity = ln(productivity of firm *p* in period *t*/average productivity of 2-digit industry in year *t*). At 5% level statistically significant p-values of t-tests are bolded.

[7] Labor productivity is obtained as $VA_t/L_t$ and TFP as $VA_t/(L_t^{2/3}K_t^{1/3})$, where VA = value added, L = number of employees and K = book value of the capital stock.

**Panel B. Identical (MZ) twins**

| | | Relative firm LP | | | | Relative firm TFP | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| **Both** | **ln(wage)** | | | | | | | | |
| | Average | 10.01 | 10.09 | 10.17 | 10.33 | 10.05 | 10.10 | 10.16 | 10.29 |
| | Std. dev. | 0.473 | 0.429 | 0.421 | 0.457 | 0.472 | 0.408 | 0.426 | 0.496 |
| | **t-tests ($H_0$)** | q2 = q1 | q3 = q2 | q4 = q3 | | q2 = q1 | q3 = q2 | q4 = q3 | |
| | p-values | **< 0.001** | **< 0.001** | **< 0.001** | | **< 0.001** | **< 0.001** | **< 0.001** | |
| | | **Relative firm LP** | | | | **Relative firm TFP** | | | |
| | | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| **Men** | **ln(wage)** | | | | | | | | |
| | Average | 10.19 | 10.23 | 10.34 | 10.50 | 10.21 | 10.26 | 10.33 | 10.46 |
| | Std. dev. | 0.462 | 0.407 | 0.394 | 0.434 | 0.467 | 0.371 | 0.392 | 0.485 |
| | **t-tests ($H_0$)** | q2 = q1 | q3 = q2 | q4 = q3 | | q2 = q1 | q3 = q2 | q4 = q3 | |
| | p-values | **0.001** | **< 0.001** | **< 0.001** | | **< 0.001** | **< 0.001** | **< 0.001** | |
| | | **Relative firm LP** | | | | **Relative firm TFP** | | | |
| | | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| **Women** | **ln(wage)** | | | | | | | | |
| | Average | 9.83 | 9.87 | 9.93 | 10.04 | 9.86 | 9.87 | 9.90 | 10.03 |
| | Std. dev. | 0.422 | 0.369 | 0.336 | 0.352 | 0.416 | 0.335 | 0.350 | 0.391 |
| | **t-tests ($H_0$)** | q2 = q1 | q3 = q2 | q4 = q3 | | q2 = q1 | q3 = q2 | q4 = q3 | |
| | p-values | **0.044** | **< 0.001** | **< 0.001** | | 0.610 | **0.019** | **< 0.001** | |

Notes: See panel A.

Several findings emerge from table 1. Firstly, average wages increase as we move from bottom to top quartiles of the productivity distribution. In addition, wage differences between quartiles of productivity distribution are statistically significant.[8] Secondly, labor productivity affects wages more strongly than TFP, as can be expected. Thirdly, men's wages increase more with increases in firm productivity than women's. Fourthly, men's average wages are higher than women's average wages in respective quartiles. This finding depicts the gender wage gap between men and women. Combined, two latter findings suggest that analyzing men and women separately is justified.

Definitions for variables included in regressions are found in Appendix A. Standard descriptive statistics tables for variables included in regressions are found in Appendix B. I find that approximately 60 percent of twins in the sample are men. Proportion of men does not differ between full twin sample and identical twin sample. Larger share of men in the estimation sample can stem from their higher likelihood to be working in private sector. Approximately one third of twins in the estimation sample are identical, which applies to the original, raw twin data as well. Descriptive statistics reveal that twins in the data are, on average, 47 years old and are thus, on average, seven years older than the average employee working in the same firm with them. Men have, on average, one more year of schooling (12 years) than women (11 years). Men are working in firms where the share of female employees is lower and

[8] The only exception are average wages of identical women twins in two bottom quartiles when relative firm TFP is the productivity measure.

average wages are higher than women which implies selection by gender. This selection into different industries, firms and occupations can potentially explain why productivity affects men's and women's wages differently. Men are more often married than women and have a higher number of underage children than women.

One of the key identifying assumptions in WT and WT-FD estimations is that at least some identical twin pairs need to be working in different firms at given time period. This variation is examined in table 2. I have split the full twin sample along two dimensions: identicalness and gender of the twins. I find that identical twins work more likely in same firm than fraternal twins. 68 percent of identical female twins work in different firms whereas only 61 percent of identical male twins work in different firms. For fraternal twins these shares are 82 percent for women and 79 percent for men. However, there is variation in identical twins' employers that enables WT identification.

**Table 2. Twin pairs working in different firms**

| | **All** | | | **DZ** | | | **MZ** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Both | Men | Women | Both | Men | Women | Both | Men | Women |
| Percentage share (%) | 73.8 | 72.2 | 76.3 | 80.0 | 79.0 | 81.6 | 63.4 | 60.8 | 67.6 |
| No. of observations | 12323 | 7300 | 5023 | 8353 | 5000 | 3353 | 3970 | 2300 | 1670 |

Notes: All = full twin sample, DZ = fraternal twins, MZ = identical twins, Both = men and women included.

# 5 Do high productivity firms pay higher wages?

## 5.1. Estimation results

I start by estimating OLS and individual FE regressions separately for full twin sample and identical twin sample. Results of these regressions are given in table 3, where the coefficient values for relative productivity variable are reported. I have performed regressions separately for men and women. Four observations can be made. Firstly, values of productivity coefficients are very similar for full twin sample and sample including only identical twins. Secondly, coefficient values are generally lower for women than men. Thirdly, labor productivity affects wages more than TFP. Fourthly, according to OLS and individual FE regressions firm productivity affects earnings of an individual positively and statistically significantly. Productivity coefficients are less precisely estimated for identical twin sample. OLS estimates for relative productivity are larger than or equal to individual FE estimates in all specifications. According to OLS estimates one percent increase in relative productivity increases wages by 0.01 to 0.06 percent, whereas individual FE estimates suggest 0.01 to 0.04 percent increase. The lowest coefficient values are obtained when firm dummies are included in the regressions.

To see more concrete implications of these coefficient values, according to baseline OLS results, when neither ability nor unobserved firm heterogeneity are controlled for, one standard deviation increase in relative firm labor productivity increases women's wages by 2.3 percent and men's wages by 3.3 percent. Respectively, one standard deviation increase in TFP increases women's wages by 1.3 percent and men's wages by 1.5 percent. According to individual FE estimates, one standard deviation increase in relative firm labor productivity increases women's wages by 1.5 percent and men's wages by 2.2 percent. Respectively, one standard deviation increase in firm TFP increases women's wages by 1.3 percent and men's wages by 1.0 percent.

For men OLS regressions including firm dummies imply 2.2 percent increase in wages as relative labor productivity increases by one standard deviation, similar increase in TFP increases wages by 1.5 to 1.9 percent. Larger increase is obtained for identical twins. For women OLS regressions including firm dummies imply 1.5 to 2.3 percent increase in wages as relative labor productivity increases by one standard deviation, similar increase in TFP increases women's wages by 0.7 to 1.5 percent. The larger increase is obtained for identical twins. Thus, OLS regressions, where unobserved individual and firm heterogeneity are not controlled for, produce larger coefficients values for productivity variable than OLS regressions containing firm controls or individual FE regressions where innate ability and in some cases also unobserved firm heterogeneity are controlled for.

**Table 3. OLS and FE results for the effects of productivity on wages**

**Panel A. Relative firm labor productivity**

| | **Men** | | | | | | | | **Women** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** | OLS | OLS | OLS | OLS | FE | FE | FE | FE | OLS | OLS | OLS | OLS | FE | FE | FE | FE |
| **Sample:** | All | All | MZ | MZ | All | All | MZ | MZ | All | All | MZ | MZ | All | All | MZ | MZ |
| Relative firm LP | 0.06*** | 0.04*** | 0.06*** | 0.04*** | 0.04*** | 0.04*** | 0.04*** | 0.03*** | 0.03*** | 0.02*** | 0.03** | 0.03*** | 0.02*** | 0.01* | 0.02*** | 0.01** |
| | (0.012) | (0.008) | (0.017) | (0.013) | (0.008) | (0.006) | (0.013) | (0.010) | (0.007) | (0.008) | (0.011) | (0.007) | (0.006) | (0.006) | (0.006) | (0.005) |
| Region, industry and year controls | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Firm controls | no | yes | no | yes | no | yes | no | yes | no | yes | no | yes | no | yes | no | yes |
| # observations | 20500 | 20500 | 6785 | 6785 | 20500 | 20500 | 6785 | 6785 | 13435 | 13435 | 4773 | 4773 | 13435 | 13435 | 4773 | 4773 |

Notes: Equations refer to equations (2) and (3). Standard errors are clustered at individual level. All = full twin sample, MZ = identical twins. Significance levels: *** = 1%, ** = 5%, * = 10%. All regressions contain individual and firm controls. Individual controls: age, age2, age3, age4, years of schooling, house owner -dummy, married -dummy, no of children under 7 years, no of children 7-18 years old. Firm controls: average wage of employees, average age of employees, average seniority of employees, share of female employees, no of employees, R&D-dummy, global-dummy. Relative firm productivity = ln(productivity of firm *p* in year *t*/average productivity of 2-digit industry in year *t*). LP = labor productivity, TFP = total factor productivity.

**Panel B. Relative firm TFP**

| | **Men** | | | | | | | | **Women** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** | OLS | OLS | OLS | OLS | FE | FE | FE | FE | OLS | OLS | OLS | OLS | FE | FE | FE | FE |
| **Sample:** | All | All | MZ | MZ | All | All | MZ | MZ | All | All | MZ | MZ | All | All | MZ | MZ |
| Relative firm TFP | 0.03*** | 0.03*** | 0.03** | 0.04*** | 0.02*** | 0.03*** | 0.02*** | 0.03*** | 0.02** | 0.01* | 0.02** | 0.02** | 0.02*** | 0.02*** | 0.02*** | 0.01* |
| | (0.011) | (0.007) | (0.017) | (0.014) | (0.006) | (0.006) | (0.009) | (0.010) | (0.007) | (0.007) | (0.011) | (0.007) | (0.005) | (0.006) | (0.008) | (0.006) |
| Region, industry and year controls | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Firm controls | no | yes | no | yes | no | yes | no | yes | no | yes | no | yes | no | yes | no | yes |
| # observations | 20453 | 20453 | 6765 | 6765 | 20453 | 20453 | 6765 | 6765 | 13353 | 13353 | 4747 | 4747 | 13353 | 13353 | 4747 | 4747 |

Notes: See panel A.

Because descriptive analysis gave a reason to believe that firm switchers and stayers differ from each other in various respects, I have performed individual FE regressions separately for subsamples of firm switchers and stayers. Results of these regressions are found in Appendix C. For women these results imply that stayers working in relatively high productivity firms are paid higher wages, whereas firm switchers do not obtain higher wages for working in relatively high productivity firms after ability and unobserved firm heterogeneity are controlled for. For men there is some evidence that firm switchers obtain higher wages in relatively high productivity firms, whereas firm stayers may not. This tendency is observed especially for identical twins.

Results of WT and WT-FD regressions are given in table 4. WT regressions control directly for unobserved ability and firm dummies are included to control for unobserved firm heterogeneity. WT-FD regressions control for unobserved ability and unobserved firm heterogeneity under given conditions through double differencing. These regressions include only identical twins. Three broad observations can be made. Firstly, firm productivity appears to affect men's wages statistically significantly in WT-FD regressions after innate ability and unobserved firm heterogeneity are controlled for. Secondly, similarly to OLS and individual FE regressions values of productivity coefficients are larger for men than women. Productivity coefficients for women are not statistically significant and their values are very close to zero or slightly negative. Thirdly, restrictions to the estimation sample drop the number of observations especially for women in WT-FD regressions, which may affect the precision of results.

**Table 4. WT and WT-FD estimates for the effects of productivity on wages**

**Panel A. Relative firm labor productivity**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| **Method:** | WT | WT | WT-FD | WT | WT | WT-FD |
| Relative firm LP | 0.03 | 0.02 | 0.04* | -0.01 | -0.03 | 0.00 |
| | (0.024) | (0.025) | (0.023) | (0.017) | (0.023) | (0.020) |
| Region, industry and time controls | yes | yes | yes | yes | yes | yes |
| Firm controls | no | yes | no | no | yes | no |
| # observations | 1994 | 1994 | 457 | 1005 | 1005 | 220 |

Notes: Estimation equations refer to equations (4) and (5). Standard errors are clustered by twin pair. Significance levels: *** = 1%, ** = 5%, * = 10%. All regressions contain individual and firm controls. Relative firm productivity = ln(productivity of firm *p* in year *t*/average productivity of 2-digit industry in year *t*). LP = labor productivity, TFP = total factor productivity. Regressions include only identical twins.

**Panel B. Relative firm TFP**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| **Method:** | WT | WT | WT-FD | WT | WT | WT-FD |
| Relative firm TFP | 0.03 | 0.02 | 0.05** | 0.00 | -0.01 | -0.01 |
| | (0.022) | (0.025) | (0.024) | (0.019) | (0.023) | (0.021) |
| Region, industry and time controls | yes | yes | yes | yes | yes | yes |
| Firm controls | no | yes | no | no | yes | no |
| # observations | 1982 | 1982 | 452 | 996 | 996 | 218 |

Notes: See panel A.

None of the productivity coefficients from WT regressions controlling for innate ability are statistically significant. However, WT regressions that control for innate ability imply for men a 1.7 percent increase in wages if firm productivity increases by one standard deviation. The effect is of the same magnitude for both productivity measures and quantitatively similar to the effects obtained from OLS and FE regressions. For women WT regressions that only control for innate ability imply that one standard deviation increase in firm labor productivity increases wages by -0.4 percent and that firm TFP does not affect women's wages at all.

For women WT regressions that also control for unobserved firm heterogeneity suggest a -2.5 percent increase in wages if labor productivity increases by one standard deviation and -0.7 percent increase for similar change in TFP. Results of these regressions are statistically insignificant. For men WT regressions that also control for unobserved firm heterogeneity imply a 1.1 percent increase in wages in firm productivity increases by one standard deviation. The effect is of the same magnitude for both productivity measures and quantitatively similar to the ones obtained from OLS and FE estimations, however, statistically insignificant.

The productivity coefficient from WT-FD regressions is positive and statistically significant for men. One standard deviation increase in firm labor productivity implies a 1.6 percent increase in men's wages. One standard deviation increase in firm TFP implies a 2.1 percent increase in men's wages. For women WT-FD regressions produce productivity coefficients that are of very similar magnitude and statistically insignificant as WT regressions that control for innate ability. Thus, based on WT and WT-FD regression results, firm productivity does not affect women's wages.

## 5.2. Robustness

To study the robustness of the estimation results, a number of robustness checks are performed. Firstly, industries are classified at 4-digit level instead of 2-digit level. Secondly, productivity is measured at plant level instead of firm level. However, plant level productivity measures are obtained only for manufacturing industries. Thirdly, productivity is measured as logarithmic productivity instead of relative productivity. None of these robustness checks affects the qualitative results obtained earlier. If productivity is measured at plant level, productivity coefficients are of similar magnitude as at firm level but due to decreased precision in estimation, coefficients are not statistically significant. If productivity is measured in logarithms, absolute values of productivity coefficients increase. However, the results remain qualitatively intact.

## 5.3. Discussion

Estimation results imply that after innate ability and unobserved firm heterogeneity are controlled for, high productivity firms pay higher wages to men. Thus, this finding accords with monopsonistic theories of labor market. For women the results are less straight forward to interpret. Individual FE regressions and individual FE regressions for firm stayers suggest that high productivity firms pay their female employees higher wages, whereas no such effect emerges in FE regressions for firm switchers. WT and WT-FD regressions produce statistically insignificant results for women as well. Differences between individual FE and WT regressions can stem from the differential sources of identification in controlling for unobserved ability. FE utilizes variation within an individual, whereas WT and WT-FD utilize variation between identical twins.

The estimation model assumes that error term consists of four additive components: time effects, innate ability, firm heterogeneity and standard i.i.d. error, which is an often used formulation in literature (Andrews et al. 2006). In this study an additional assumption regarding the error term is that innate ability is assumed to be equal between identical twins (Ashenfelter & Kruger 1994). If ability has other, individual level components which are correlated with productivity of firm individual works in, WT estimations produce biased results. Previously, Ashenfelter and Rouse (1998) and Isacsson (1999) have examined the identical ability assumption and do not find strong evidence against it. In this study magnitudes of coefficients are relatively close to each other in FE, WT and WT-FD regressions. The twin sample observes twins at more mature stages of their careers, as the average age of identical twins in the data is 47 years. It is possible that during the years between birth and adulthood identical twins face idiosyncratic shocks that differentiate their originally identical abilities. However, if these possible individual level components were time invariant, WT-FD estimation would solve this inconsistency.

Men's wages increase more with increases in firm productivity than women's. Similar evidence has been obtained in rent sharing context by Nekby (2003). Reasons behind this heterogeneity between genders can be various. Already descriptive statistics implied that men tend to work in firms where larger proportion of employees are men. The opposite was found for women. This suggests that there is selection by gender that in part can affect the results. It is possible that men are selected into industries, firms and occupations where especially labor productivity is more easily observable by employers. If in addition shirking was especially harmful in these occupations, efficiency wages could explain the bigger impact of firm productivity on men's wages.

Finland is a highly unionized country (see e.g. Schmitt & Mitukiewicz 2011). However, labor unions have different goals. Some unions emphasize wages whereas others emphasize employment (Oswald 1985). Traditionally men have been working in industries where labor unions tend to emphasize wages, such as manufacturing of pulp and paper and metal industry, whereas women have been working in service industries, where unions often place more weight on maximizing employment. These differences in bargaining power and labor union objectives may in part explain the differences in wage formation between men and women.

Results imply that more able individuals are sorted into more productive firms and are paid higher wages. This is shown in the upwards bias of OLS regressions. In most of the models, unobserved firm heterogeneity appears to be positively correlated with firm productivity and wages. If unobserved firm heterogeneity is interpreted as management quality this means that high quality managers work in high productivity firms and pay employees higher wages. Similar observations regarding unobserved ability and firm heterogeneity have been made by Van Reenen (2011). WT-FD regressions for men imply that management quality affects firm productivity positively but wages negatively. However, this can stem from restrictions placed on estimation sample.

Compared to earlier empirical literature examining connections between firm profitability and wages, the effects of firm productivity on wages appear somewhat lower. Yet, I recognize that the results of this study are not fully comparable to results from previous rent sharing literature due to differences in institutions, datasets, estimation approach and timing. Thus, there may be persistent earnings gaps between individuals working in high and low productivity firms that cannot be explained with selection by ability or unobserved firm heterogeneity. At yearly level these effects are likely to be of smaller magnitude than more transitory earnings shocks created by firm profitability.

# 6 Conclusions

This study has investigated the relationship between firm productivity and wages using panel data of Finnish twins. Previous literature has mostly focused on estimating the relationship between firm profitability and wages but I argue that since firm productivity is more persistent (Foster, Haltiwanger & Syverson 2008) it is important to examine its effects on wage determination. The presence of unobserved individual and firm heterogeneities complicates estimation and need to be taken into account to evoke the causal effect between firm productivity and wages. To control for unobserved individual heterogeneity, in addition to using traditional individual FE estimation, I resort to data of identical twins and method of WT differencing. This method is discussed for example in Ashenfelter and Kruger (1994) and it hinges on the assumption that identical twins are identical also by their abilities. Unobserved firm heterogeneity requires more subtle approaches where assumptions on the estimation sample and its error term play significant roles. Thus, several alternative estimation approaches are adopted.

Results of this study have elements that accord with monopsonistic, bargaining and efficiency wage models. Like monopsonistic models predict, this study suggests that firm productivity affects wages, but the magnitudes are heterogeneous between genders. It appears that men who work in high productivity firms obtain higher wages even after unobserved individual and firm heterogeneity are controlled for. For women these effects are of smaller magnitude and several models suggest that firm productivity has no effect on wages. This can at least partly stem from selection by gender into different industries, firms and occupations as well as from different objectives and bargaining power of labor unions. Traditionally men have been more inclined working in industries, such as manufacturing of pulp and paper or manufacturing of metal products that are characterized by strong labor unions with an emphasis on wages instead of employment. It is also possible that men work in occupations in which labor productivity is easily observable and shirking is particularly harmful. This would accord with efficiency wage models. However, due to lacking occupation level information, occupational selection and its effects cannot be directly tested in this study.

As Van Reenen (2011), also this study supports the notion that more able individuals are sorted into more productive firms and are paid higher wages. The drop in the value of productivity coefficient occurring after unobserved individual heterogeneity is controlled for demonstrates this. On the other hand selection by ability does not fully explain the positive relationship between firm productivity and wages. The relationship between unobserved firm heterogeneity, firm productivity and wages is more complex. Even if in most cases unobserved firm heterogeneity is positively correlated with firm productivity and wages, there is some evidence that unobserved firm heterogeneity can be positively linked to firm productivity but negatively to wages. However, this evidence is very limited and can be driven by assumptions placed on the estimation sample. Unobserved firm heterogeneity does not fully explain the positive relationship between firm productivity and wages, either.

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**Appendix A. Variables included in regressions**

| Variable | Definition |
|---|---|
| ln(wage) | ln(yearly salary income + yearly income from entrepreneurial activities) |
| Relative firm LP | ln(labor productivity of firm *p* in year *t* /average labor productivity of 2-digit industry in year *t* ) |
| Relative firm TFP | ln(TFP of firm *p* in year *t* /average TFP of 2-digit industry in year *t* ) |
| | |
| Individual controls: | |
| Age | Age in years |
| $Age^2$ | $(Age\ in\ years)^2$ |
| $Age^3$ | $(Age\ in\ years)^3$ |
| $Age^4$ | $(Age\ in\ years)^4$ |
| Years of schooling | No. of years of schooling |
| Houseowner | 1, if one owns a house, 0 otherwise |
| Married | 1, if one is married or cohabiting, 0 otherwise |
| No. of children < 7 | No. of children under seven years of age |
| No. of children 7-18 | No. of children over seven but under 18 years of age |
| | |
| Firm controls: | |
| Age of employees | Average age of employees in a firm |
| Firm seniority | Average seniority of employees in a firm (in months) |
| Women share | Share of women among employees |
| Wage | Average wage in a firm |
| Size | Number of employees |
| R&D | 1 if firm performs R&D, 0 otherwise |
| Global | 1 if firm imports, exports or is an MNE, 0 otherwise |

**Appendix B. Descriptive statistics**

**Panel A. Full twin sample**

| | | Both | | | Men | | | Women | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | No. of obs. | Average | Std. dev. | No. of obs. | Average | Std. dev. | No. of obs. | Average | Std. dev. |
| ln(wage) | 35995 | 10.15 | 0.450 | 21746 | 10.29 | 0.425 | 14249 | 9.92 | 0.392 |
| Relative firm LP | 35101 | -0.13 | 0.630 | 21202 | -0.09 | 0.545 | 13899 | -0.21 | 0.736 |
| Relative firm TFP | 34972 | -0.10 | 0.546 | 21155 | -0.07 | 0.484 | 13817 | -0.13 | 0.628 |
| | | | | | | | | | |
| Individual controls: | | | | | | | | | |
| Age | 35995 | 47.21 | 5.895 | 21746 | 47.12 | 5.848 | 14249 | 47.37 | 5.964 |
| $Age^2$ | 35995 | 2264.00 | 558.82 | 21746 | 2254.04 | 552.456 | 14249 | 2279.20 | 568.089 |
| $Age^3$ | 35995 | 110179.1 | 40482.94 | 21746 | 109420.6 | 39880.97 | 14249 | 111336.6 | 41359.37 |
| $Age^4$ | 35995 | 5437977 | 2653754 | 21746 | 5385893 | 2604772 | 14249 | 5517463 | 2724986 |
| Years of schooling | 35995 | 11.66 | 2.533 | 21746 | 11.97 | 2.635 | 14249 | 11.18 | 2.285 |
| Houseowner | 35995 | 0.83 | 0.376 | 21746 | 0.85 | 0.360 | 14249 | 0.80 | 0.399 |
| Married | 35995 | 0.76 | 0.424 | 21746 | 0.80 | 0.400 | 14249 | 0.71 | 0.453 |
| No. of children < 7 | 35995 | 0.11 | 0.401 | 21746 | 0.15 | 0.460 | 14249 | 0.07 | 0.282 |
| No. of children 7-18 | 35995 | 0.58 | 0.862 | 21746 | 0.65 | 0.920 | 14249 | 0.48 | 0.754 |
| | | | | | | | | | |
| Firm controls: | | | | | | | | | |
| Age of employees | 35101 | 40.24 | 3.456 | 21202 | 40.59 | 3.252 | 13899 | 39.71 | 3.683 |
| Firm seniority | 35101 | 124.91 | 58.088 | 21202 | 127.71 | 60.049 | 13899 | 120.64 | 54.689 |
| Women share | 35101 | 0.36 | 0.249 | 21202 | 0.25 | 0.177 | 13899 | 0.53 | 0.251 |
| Wage | 35101 | 2147.09 | 650.230 | 21202 | 2256.28 | 613.764 | 13899 | 1980.52 | 668.736 |
| Size | 35101 | 21973.29 | 43385.39 | 21202 | 21993.6 | 41982.74 | 13899 | 21942.31 | 45443.25 |
| R&D | 35101 | 0.08 | 0.266 | 21202 | 0.08 | 0.275 | 13899 | 0.07 | 0.252 |
| Global | 35101 | 0.69 | 0.464 | 21202 | 0.71 | 0.455 | 13899 | 0.65 | 0.476 |

Notes: For detailed information on variables, see Appendix A. Both = men and women included. Averages are obtained as averages over years 1990-2004.

**Panel B. Identical twins**

| Variable | No. of obs. | Both Average | Std. dev. | No. of obs. | Men Average | Std. dev. | No. of obs. | Women Average | Std. dev. |
|---|---|---|---|---|---|---|---|---|---|
| ln(wage) | 12297 | 10.15 | 0.461 | 7222 | 10.31 | 0.442 | 5075 | 9.91 | 0.378 |
| Relative firm LP | 11968 | -0.15 | 0.657 | 7017 | -0.08 | 0.553 | 4951 | -0.25 | 0.770 |
| Relative firm TFP | 11922 | -0.10 | 0.570 | 6997 | -0.06 | 0.486 | 4925 | -0.15 | 0.667 |
| Individual controls: | | | | | | | | | |
| Age | 12297 | 47.32 | 5.962 | 7222 | 47.30 | 5.962 | 5075 | 47.34 | 5.962 |
| $Age^2$ | 12297 | 2274.49 | 565.433 | 7222 | 2272.96 | 563.535 | 5075 | 2276.68 | 568.174 |
| $Age^3$ | 12297 | 110984.5 | 40976.26 | 7222 | 110863.8 | 40688.85 | 5075 | 111156.2 | 41385.23 |
| $Age^4$ | 12297 | 5493014 | 2686688 | 7222 | 5483872 | 2657109 | 5075 | 5506024 | 2728438 |
| Years of schooling | 12297 | 11.76 | 2.517 | 7222 | 12.11 | 2.681 | 5075 | 11.26 | 2.169 |
| Houseowner | 12297 | 0.83 | 0.377 | 7222 | 0.83 | 0.374 | 5075 | 0.82 | 0.381 |
| Married | 12297 | 0.77 | 0.419 | 7222 | 0.80 | 0.398 | 5075 | 0.73 | 0.444 |
| No. of children < 7 | 12297 | 0.11 | 0.408 | 7222 | 0.15 | 0.488 | 5075 | 0.05 | 0.243 |
| No. of children 7-18 | 12297 | 0.58 | 0.880 | 7222 | 0.65 | 0.954 | 5075 | 0.47 | 0.748 |
| Firm controls: | | | | | | | | | |
| Age of employees | 11968 | 40.17 | 3.485 | 7017 | 40.51 | 3.305 | 4951 | 39.69 | 3.674 |
| Firm seniority | 11968 | 125.00 | 58.557 | 7017 | 127.88 | 60.860 | 4951 | 120.92 | 54.877 |
| Women share | 11968 | 0.37 | 0.250 | 7017 | 0.26 | 0.178 | 4951 | 0.53 | 0.249 |
| Wage | 11968 | 2138.35 | 652.803 | 7017 | 2260.09 | 620.931 | 4951 | 1965.80 | 658.021 |
| Size | 11968 | 21535.27 | 44450.88 | 7017 | 21310.1 | 43290.93 | 4951 | 21854.39 | 46047.37 |
| R&D | 11968 | 0.08 | 0.266 | 7017 | 0.08 | 0.278 | 4951 | 0.07 | 0.248 |
| Global | 11968 | 0.69 | 0.463 | 7017 | 0.72 | 0.449 | 4951 | 0.65 | 0.478 |

Notes: See panel A.

**Appendix C. FE regressions for stayers and switchers**

**Panel A. Relative firm labor productivity**

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample:** | All | MZ | All | MZ | All | MZ | All | MZ | All | MZ | All | MZ |
| **Status:** | Stayers | Stayers | Switchers | Switchers | Switchers | Switchers | Stayers | Stayers | Switchers | Switchers | Switchers | Switchers |
| Relative firm LP | 0.04*** | 0.01 | 0.04*** | 0.05*** | 0.04*** | 0.04*** | 0.02*** | 0.03*** | 0.02*** | 0.02*** | 0.01 | 0.01* |
| | (0.011) | (0.019) | (0.009) | (0.015) | (0.007) | (0.011) | (0.006) | (0.009) | (0.007) | (0.007) | (0.008) | (0.007) |
| Region, industry and year controls | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Firm controls | no | no | no | no | yes | yes | no | no | no | no | yes | yes |
| # observations | 4181 | 1217 | 16319 | 5568 | 16319 | 5568 | 2785 | 847 | 10650 | 3926 | 10650 | 3926 |

Notes: Equations refer to equation (3). Standard errors are clustered at individual level. All = full twin sample, MZ = identical twins. Significance levels: *** = 1%, ** = 5%, * = 10%. All regressions contain individual and firm controls. Individual controls: age, age2, age3, age4, years of schooling, house owner -dummy, married -dummy, no of children under 7 years, no of children 7-18 years old. Firm controls: average wage of employees, average age of employees, average seniority of employees, share of female employees, no of employees, R&D-dummy, global-dummy. Relative productivity is measured as percentage deviation from 2-digit industry level average productivity. LP = labor productivity, TFP = total factor productivity. Stayers = individuals who do not change their employer. Switchers = individuals who change their employer at least once.

**Panel B. Relative firm TFP**

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample:** | All | MZ | All | MZ | All | MZ | All | MZ | All | MZ | All | MZ |
| **Status:** | Stayers | Stayers | Switchers | Switchers | Switchers | Switchers | Stayers | Stayers | Switchers | Switchers | Switchers | Switchers |
| Relative firm TFP | 0.03*** | 0.03 | 0.02** | 0.02** | 0.03*** | 0.04*** | 0.01* | 0.03*** | 0.02*** | 0.02** | 0.01 | 0.01 |
| | (0.010) | (0.018) | (0.006) | (0.009) | (0.007) | (0.012) | (0.006) | (0.008) | (0.006) | (0.009) | (0.007) | (0.008) |
| Region, industry and year controls | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Firm controls | no | no | no | no | yes | yes | no | no | no | no | yes | yes |
| # observations | 4178 | 1216 | 16275 | 5549 | 16275 | 5549 | 2782 | 847 | 10571 | 3900 | 10571 | 3900 |

Notes: See Panel A.