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The Interplay of Ageing Population and ICT

To what extent can progress in information technology compensate the expected decrease in total output due to an ageing population, within the German manufacturing sector?

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Abstract

On a global scale, life expectancy has increased, and birth rates have reduced. This has both decreased the size of the employed workforce and has negatively affected total factor productivity (TFP) and total output. This research looks at whether technology, and ICT in particular, can counter the effects of an aging population on the German manufacturing sector. Using a Cobb-Douglas production function, we calculate and compare the magnitude of such effects. While we conclude that an ageing population has a negative impact on employment, output, and productivity, findings suggest that the effect of ICT on total output is not statistically significant, and that its relative productivity does not differ from that of non-ICT capital. Our findings add to the existing literature by providing an up to date view of the phenomena and a more comprehensive understanding of its linkage with information technology in German manufacturing sector.

Key words: ageing population, ICT, technology, output, Germany, manufacturing sector

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1. Introduction

Ageing population is a worldwide phenomenon. According to one United Nations (2017) report, 177 of 195 countries are experiencing a significant increase in the share and number of elderly people (64+) in the total population. As the population ages, Prskawetz et al. (2008) argue that there will be a change in the labour force, particularly, the number of employed workers may decrease, and the average age of the labour force will increase. Liu and Westelius (2016) found that this will result in a decline in labour productivity and lower total output as it is assumed by Vaportazis, Clausen and Gow (2017) that older generations will be more reluctant to adapt new technologies than the younger generation. At present, we do not know to what extent an ageing population will affect total output. This research seeks to investigate the effects of an ageing population on labour input and on Total Factor Productivity (TFP) which is measured as the ratio of aggregate output to aggregate inputs. TFP is the portion of growth in output not explained by inputs. We define output as the value of goods produced in any given sector. TFP depends on two main elements: the degree of modernisation of capital and skills of the workforce (Artus, 2016). The first research question we therefore seek to address is:

"Could ageing population negatively affect TFP and labour input, which can then decrease the total output in German manufacturing sector?"

The use of new technologies has paved the way for production of goods more efficiently. To study its impacts on TFP, we focus solely on Information and Communication Technology (ICT), such as computer systems and the Internet, as ICT has played a dominant role in creating revolutionary change in production in the last 20 years (from OECD, 2014). Thus, in this paper we examine in detail the relative productivities of ICT and of old workers (defined as over 50 years old), and the effect of the interactions between the proportions of the same on TFP. So here arises our second research question, looking at the joint impact of the two factors:

“To what extent has progress in Information & Communication technology compensated for the decrease in total output caused by ageing population?”

In the paper, we focus on the manufacturing sector specifically as it is most affected by the ageing population in comparison to other sectors such as agriculture (Ours & Stoeldraijer, 2010). In addition, the study is limited to Germany not only for practical reasons, such as the accessibility and availability of the data, but also because Germany satisfies the following characteristics. Firstly, the country has a strong manufacturing base, making up 25.8% of GDP (Statistisches Bundesamt, 2019). Secondly, Germany has experienced an ageing population in recent decades and the situation is forecasted to worsen in the future - the percentage of 64+ population in 2016 was 21.1% and is projected to be 26.1 % in 2030 (European Commission, 2017). This is currently one of the highest among all European countries.

The structure of the paper is laid out as follows: in Section two, we will review existing research and literature relating to our topic. Section three will introduce our methodology and in Section four, key findings will be presented. In Section five we will discuss the implications of our study and finally, in Section six, we draw conclusions from our research and attempt to answer our proposed research questions.

2. Literature Review

The following literature review positions our paper within the existing field of research. This section will begin by exploring the relationship between ageing populations and labour markets to explain the problem that this paper aims to address. Secondly, we review literature which focus on the existing use of econometric models to determine the effects of ageing populations on the economy, and thirdly we provide an overview of existing research looking at ageing populations and the German manufacturing sector.

2.1. Ageing population and the labour force

There are several studies exploring the effects an ageing population can have on a country's worker-demographic. The studies highlight two key adjustments occurring the labour market, firstly the median age of workers has been and is projected to increase consistently in developed economies, secondly the proportion of the population participating in the labour force is projected to decrease. This latter point, arising from increased life expectancy and a lower birth rate (Fougere & Merette, 1999), placing downward pressure on the supply of labour.

In addition to possible implications of an older workforce on worker productivity, which will be discussed in the next sub-section, research from the Office for National Statistics has also highlighted a potentially less mobile labour force (Dixon, 2003). Older workers are less willing to move for work, due to potential tenure-related benefits with their incumbent firms and also due to the reduced pay-off from moving when moving costs are factored in (Groot & Verberne, 1997), which is consistent with the view that an older population negatively effects the supply of labour (Kochling, 2003; Acemoglu & Restrepo, 2017).

Overall, research has been conclusive in connecting an ageing population to the demographics of the labour force. There have been at least two studies (Kirpal & Kühl, 2006; Kochling, 2003) looking at the effects of an ageing population on the Germany, however neither uses recent data. Part of the analysis in this paper will seek to verify previous conclusions, linking ageing population to a reduced labour force, using more recent data. However, the analysis within this paper will analyse the overall macro effects of an ageing population on the labour force, and not the specific drivers.

2.2. Ageing population and production

Most studies on the effect of ageing demographics focus either on changes in TFP or on labour input in individual countries. In terms of the effects on TFP, Liu and Westelius' (2016) study in Japan suggests that the ageing of the working age population and TFP are negatively correlated. In particular, a 1% shift from the 40 to 50-years-old age group will decrease the productivity by 1.3%. Ours & Stoeldraijer's (2010) study looked at the relationship of ageing population and productivity in Dutch companies. It also used the Cobb-Douglas production function under the assumption that workers of different age groups are perfect substitutes for one another (i.e. younger workers could completely replace older workers) but that they may have different marginal productivity. The results of the research show that the 'value added' of workers in the manufacturing sector declines sharply when workers turn 50 in comparison to other industries such as wholesale trade and commercial service. Such results have influenced our decision to narrow the scope to the manufacturing sector.

Thun et al's (2007) study regarding German manufacturing sector found that 37% of the workforce of companies in this sector is made up of 50-year-old and older workers. The group of the '40-50-year-olds' represents 30% of the workforce in the sample companies who will have turned 50 years or older in 10 years. This suggests that the ageing population does have a large impact on the structure of the workforce in manufacturing sector. This has created several problems because older workers are considered to have problems concerning flexibility, the willingness to learn, their learning, reactivity, physical and psychological resilience. Therefore, the question about how countries can tackle the problem of an ageing population has been raised.

2.3. ICT technological change and production

Most of the macroeconomic research concluded that ICT was responsible for much of the acceleration in productivity growth. (Ark, Inklaar and McGuckin 2003). When looking at German manufacturing sector specially, by using gross-output growth accounting exercise, the research conducted by Strobel in 2016 concludes that imported ICT intermediate inputs played a dominate role in boosting productivity and total output in German manufacturing sector through both direct investment in ICT and spill over effect from upstream to downstream sector originating from implementation of new ICT technologies in the production process of final goods.

The study by Ilmakunnas & Miyakosh (2013) which looked at the joint effect of TFP and ICT is more significant in shaping our research paper. The study draws upon the Cobb-Douglas production function and dividing labour into groups according to both age groups and levels of skills. Nonetheless, this model ignores the fact that labour force will shrink as a result of ageing population. Therefore, we aim to develop the model will take this effect into account and the detailed modifications will be explained in Section 3.

3. Methodology

We study the effects of labour, ICT and the interplay between the two on the level of output, and to do so assume a Cobb-Douglas production function with capital and labour inputs:

$$Y = AK^{\alpha}L^{\beta} \tag{1}$$

A is the total factor productivity Index. Growth in TFP is portion of growth in output not explained by growth in inputs (capital and labour). Taking logarithms on both sides of the equation, we get:

$$\ln(A) = \ln(y) - \alpha\ln(K) - \beta\ln(L) = \theta \tag{2}$$

In line with the primary purpose of this paper, the differential effect of the labour age is studied and all other parameters of the worker, including skill level and gender characteristics are left out on the grounds of being irrelevant to the empirical analyses that follows. This paper, as opposed to ones presented previously, such as the one by Ilmakunnas and Miyakoshi (2013), focuses, among other things, on the effects of an ageing population on 1) labour size and 2) labour structure, identifying how the individual elements of the production function change the total output Y. Whether employment does in-fact experience a change or not will be studied in the 'Findings' section through the following multiple regression model.

$$LabourManufacture = \beta_0 + \beta_1 PercentOlder + \beta_2(LabourForce) + \lambda_t + \in_t \tag{3}$$

Where '*PercentOlder*' captures the proportion of the population above the age of 50, and '*LabourManufacture*' the number of people employed in the manufacturing sector of Germany (the regression also adds a control variable in the form of '*LabourForce*' which keeps the 'size' of the labour force constant and controlled for). λ_t is the term for time fixed effects and ε_t is error term.

The second part of this paper focuses on studying the effects of a 'modified TFP' measure on output and labour inputs. The formulation provided through equation (2) is enough to understand the general relationship between TFP change, output change and inputs change. However, it cannot tell us what would be the economic factors that affect the TFP. To investigate the effects of Information and Communication Technology (ICT) and age, and the effects of their relative productivities on TFP and subsequently on output, we need to include these factors in the production function. We thus use updated figures K* and L* which are the quality-adjusted capital and labour inputs.

The Updated figures for L and K include the figures for productivity and shares.

$$L^* = \phi_o L_o + \phi_y L_y = L(\phi_o s_o + \phi_y s_y) \quad (4)$$

$$K^* = \psi_{ICT} K_{ICT} + \psi_{non-ICT} K_{non-ICT} = K(\psi_o s_{ICT} + \psi_y s_{non-ICT}) \quad (5)$$

In (4), the quality-adjusted labour input L^* is defined as a weighted average of the young and old workers, where their productivities ϕ_o and ϕ_y are the weights. L_o is the number of old workers, and L_y, the number of young workers. $S_o = L_o/L$ is the share of old workers, $S_y = L_y/L$ is the share of young workers.

In (5), similarly the quality-adjusted capital input K^* is defined as a weighted average of the ICT capital K_{ICT} and non-ICT capital $K_{non-ICT}$, where their respective productivity Ψ_{ICT} and

$\Psi_{non-ICT}$ are the weights. $S_{ICT} = K_{ICT}/K$ measures the ICT capital as a share of the total capital. Similarly, $S_{non-ICT} = K_{non-ICT}/K$.

Recall (2), replacing K and L with K* and L*:

$$\ln(Y) = \ln(A) + \alpha\ln(K^*) + \beta\ln(L^*) \tag{6}$$

In order to generate estimation about K using data available, appropriate approximation is needed. Here we use first-order Taylor expansion (Ilmakunnas and Miyakoshi, 2013), applying to (4) and (5):

$$\ln L^* = \ln(L(\phi_o s_o + \phi_y s_y)) = \ln L + \ln(1 + s_o(\phi_o - 1)) \approx \ln L + s_o(\phi_o - 1) \tag{7}$$

$$\ln K^* \approx \ln K + s_{ICT}(\psi_{ICT} - 1) \tag{8}$$

Replace (7) and (8) into (6) and rearranging the equation (6) gives us

$$\ln(TFP) = \theta + \psi^*_{ICT} q_{ICT} + \phi_O^{0*} s_O + \phi_{O,ICT}^{1*} s_O q_{ICT} \tag{9}$$

, where q_{ICT} = s_{ICT}, the former being used to avoid confusion during the empirical analysis, $Ln(A) = \theta$, which can be interpreted as the TFP index without incorporating the effects of productivities of labour, capital, and the interplay between the two. We use $\phi_o{}^*, \psi_{ICT}{}^*$ as relative productivities of old workers and of ICT capital respectively; assuming that the productivities of young workers and of non-ICT capital are normalized to 1, these relative productivities are simply equal to the productivities found earlier and can be substituted in the model. $\phi_o{}^* = \phi_o^{*0} + \phi_o^{*1} qICT$ shows that the productivities of workers are based on a term showing independent productivity and one term which is used to describe productivity as an interaction with the fraction of ICT used q_{ICT}, which is equal to K_{ICT}/K

In the section that follows, we study the following two effects of an ageing population- (1) The Partial, True, unbiased effect of an ageing population on the number of people employed in the manufacturing sector in Germany and hence on the total manufacturing output. Our initial hypothesis is that this will be a negative effect. (2) Afterwards, we incorporate equation (9) into the production function, including relevant controls and study whether an increase in ICT share, weighted by the relative productivity, can statistically positively affect total manufacturing output and potentially compensate for the decrease caused by an ageing population.

The data has been collected from the EU KLEMS database, OECD library, and the International Labour Organization. We use a repeated cross-sectional data where average statistics are used for the manufacturing across the 21 years from 1995 to 2015, A repeated cross section allows us to study evolution over time and control for relevant fixed effects.

4. Findings

The first task is to study the effect of an ageing population on the size of the labour force in the manufacturing sector. The model used allows us to study the effect of an increase in the percentage of people over the age of 50 on the number of people employed in the manufacturing sector in Germany. By the construction of the equation, it is evident that the size of the population and that of the labour force is being controlled for.

$$LabourManufacture_t = \beta_0 + \beta_1 PercentOlder_t + \beta_2 (LabourForce) + \lambda_t + \in_t \qquad (3)$$

It can be interpreted that as the percentage of people above the age of 50 in the population rises by 1, the employment of the manufacturing sector shrinks by 109 (Table 1) which corresponds to a 1.39% (Table 2) reduction in the percentage employed in manufacturing accounting for the same controls as before; and a reduction of 1% in the percentage employed reduces total output by 1.4% (Table 3). By controlling for the size of the labour force we ensure that the potential channels for omitted variable bias are avoided; this effect is statistically different from zero at the 0.1% significance level.

Labour Manufacture *(total employed in Manufacturing)- From Table 1*

Independent Variable (and other controls)	Coefficient	P-value (**Calculated at null hypothesis of 0 effect)**
PercentOlder	-109.88	0.001
LabourForce	0.2060	0.003

The time fixed effects require a note here. We identify that as a combination of dummy variables that can take values 0 or 1

$$\sum_{t=1}^{Tf} \lambda_i Tf_i = \lambda_1 Tf_1 + \lambda_2 Tf_2 + \lambda_2 Tf_3 + \lambda_4 Tf_4 \qquad (10)$$

Tf_1, for instance takes value 1 for years 1996-2000, and Tf_2 takes value 1 for the years 2001-2005 and so on till 2015. To avoid perfect multicollinearity, a total of 20, instead of 21 time periods are incorporated in the time fixed effects.

Now that it has been established that the effect of an ageing population on output is statistically significant, we need to study whether the productivity of ICT positively effects of total manufacturing output and whether it is enough to compensate for the decrease caused by an ageing population. To study the effects of the productivities, we use the model described above in the methodology section. Finally, an ageing population also negatively impacts productivity (TFP) by increasing the share of old workers in the manufacturing sector. With a p-value less than 0.02, it has been established with sufficient confidence that an increase in the share of old workers by 1% reduces the percentage of TFP (productivity) by approximately 2- all else controlled for.

Recall:

$$\ln(TFP) = \theta + \psi^{*}_{ICT} q_{ICT} + \phi^{0*}_{O} s_O + \phi^{1*}_{O,ICT} s_O q_{ICT} \tag{9}$$

$$\ln(y) = \alpha \ln(K) + \beta \ln(L) + \ln(TFP) \tag{2}$$

Combine (9) and (2), we have :

$$\ln(y) = \alpha \ln(K) + \beta \ln(L) + \theta + \psi^{*}_{ICT} q_{ICT} + \phi^{0*}_{O} s_O + \phi^{1*}_{O,ICT} s_O q_{ICT} \tag{11}$$

We can interpret the relative productivities of older workers & of ICT, as the partial effect of increase in the respective shares on the increase (or decrease) in output. Thus, the relative productivity of old workers, independent of ICT is the slope coefficient in the regression where the dependent variable is the total output and the independent variable is the share of old workers; this is given by ϕ^{0*}_{O}. Similarly, the productivity of ICT, independent of interaction with workers and given by ψ^{*}_{ICT}, can be interpreted as the slope coefficient in the same regression measuring the partial effect of a share of ICT on total output. And lastly, the relative productivity of the interaction of old workers and ICT is given by $\phi^{1*}_{O,ICT}$.

Thus, we now study the effect of the relative weighted productivities on the total output through the following regression model:

$$\begin{aligned}&\ln(TotalOutputMf_t) = \gamma_0 + \gamma_1 \ln(TotalCapitalMf_t) + \gamma_2 \ln(LabourManufacture_t) + \gamma_3(LabourForce_t) + \\ &\gamma_4 \ln(TFPIndex_t) + \gamma_5(Mean\_Monthly\_Earn_t) + \gamma_6(sh\_old\_manufacturing_t) \\ &+\gamma_7(q_{ICT_t}) + \gamma_8(sh\_old\_manufacturing_t X q_{ICT_t}) + \lambda_t + \in_t\end{aligned} \quad (12)$$

Findings suggest that as the share of ICT in interaction with the share of old workers ($sh\_old\_manufacturing_t Xq_{ICTt}$) increases by 0.1% the total output increases by 2.4%; this has been captured by γ_8. However, this has been measured with a very large standard error and hence is dragging the t-statistic down, raising the p-value; the finding is that this coefficient is neither statistically different from 0 nor is it statistically different from 1. A similar interpretation goes for γ_7, whose t-statistic implies that the share of ICT does not statistically differ from the share of non-ICT capital. What CAN be observed from this regression is that the productivities of an old workforce are different from 1, as shown by γ_6

Total Real Output (LOG) *(all figures for manufacturing)- From Table 3*

Independent Variable (and other controls)	Coefficient	P-value **(Calculated at null hypothesis of 0 effect)**
Sh_Old_Mf (s_o)	-2.45	0.244
Sh_ICT (q_{ICT})	-5.268	0.472
ShOld_Mf X Sh_ICT (s_o X q_{ICT})	24.06	0.384

On conducting a t-test, we found that γ_6 is statistically different from 1 at the 10% signiicance level as the absolute t statistic value is more than the petinent critical value. This implies that the productivity of an old worker is statistically different from that of a young worker and hence a change in in the share of old workers does in fact impact TFP. Thus, the weighted productivity of an old worker, evaluated at 'mean share' is

$$(\phi^{0*}_{o,ICT} X \text{ mean of share of old}) = \phi^{0*}_{o,ICT} X (\sum_{t=1}^{T} S_{o,t} / n_t) \tag{13}$$

, where n_t is the number of time periods. This would come out to -2.45 x 0.22, which is equal to -0.539 (Table 4). Finally, it is also worth noting that the effect of capital accumulation on total output is almost 3 times that of TFP (table 3), both being statistically significant.

In summary, while it was established that the differential effect of productivities of old workers is present, which does indeed negatively impact TFP, an increase in the share of ICT might not be able to compensate for the effects of an ageing population as the 'weight' for that measure, which is the productivity of ICT (independently and in interaction old labour share) is not statistically significant in its effect on Total Manufacturing Output.

5. Discussion

The purpose of this paper is to answer the question of whether information technology could be a strong enough solution to the aging problems in German manufacturing industry. Our findings suggest that information technology might not have a strong impact on productivity and output in German manufacturing industry. Our research does however, have the following three limitations:

1. This result might be subject to biased caused by data limitations. The EU-KLEMS data we used only has the data for 21 years. There is possibility that the t-statistics might become more statistically significant as the number of observations is increased and standard errors are reduced.
2. The model used does not allow for a randomized control study and therefore, inevitably our research could not be *completely* free from Omitted Variable bias.
3. Due to time constraints, our research only studied the German manufacturing industry. Hence our findings might not be able to generalisable to other countries and industries and thus have external validity concerns. In other words, our findings are sensitive to the country and industry being studied.

Our research focuses on information and communication technology, due to its prevalence in modern day manufacturing and business in general. However, productivities of other technologies could have strong positive effects on productivity and output in German manufacturing sector. For this reason, our findings should not be interpreted as saying that 'the effect of technology of any kind is not strong enough for solving aging problems'. Our findings largely apply to the case we studied. Indeed, other forms of capital, such as automation and robotics could have a strong positive impact on manufacturing due to statistically significant relative productivities. Further research needs to be conducted to study whether automation technology could compensate for the problems caused by aging populations and possibly even replace labour input in the long run. The age structure of workforce might be one explanation for the lack of statistical significance of the effect of ICT share: older workers in manufacturing are less likely to adopt new ICT technologies, despite heavy investment in ICT capitals by firms. Since we do not directly run regressions studying the relationship between ageing populations and ICT, we cannot rule out the effects of age structure on efficiency of ICT technology adoption. Again, further research is needed in this area. Due to the data & model limitations highlighted earlier, it would be difficult to justify causality between age structure and technology adoption. Lastly, mathematically finding the optimal balance between ICT capital, non-ICT capital, and labour input to maximize total output under different economic variables & scenarios could prove to be of high significance

6. Conclusion

The purpose of this paper has been to investigate the interaction effects of ageing population and ICT on total output. On the one hand, we found that ageing population has a negative impact on TFP and labour input. Ageing population has resulted in a decline in the number of employed workers in German manufacturing sector. These results are consistent with our hypothesis and intuitive reasoning. On the other hand, the impact of ICT is not as significant as we have expected. In other words, we found that increasing the share of ICT might be an exercise in futility, based on past data in the manufacturing sector, as its relative productivity does not make the effect strong enough in boosting the output to compensate for the fall in output as a result of the ageing population.

We therefore suggest that capital accumulation may have a more direct and greater influence on determining the level of output compared to TFP and its respective components. Further research could investigate the significance of capital accumulation in making up for the loss of output in the manufacturing sector and if the result implies that investment in capital does help, firms should focus more on accumulating capital than upgrading ICT. In conclusion, the model acts as a useful resource for future scholars to study the impact of ageing population on TFP and output as well as assessing the role of ICT in other sectors such as agriculture, retail, financial service, etc.

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Appendix

H_0: $\gamma_6 = 1$ & H_1: $\gamma_6 \neq 1$ where the t statistic is $(\widehat{\gamma_6} - 1)/se(\widehat{\gamma_6})$

⇨ (-2.45-1)/1.95 = -1.76 (the absolute value of which is less than 1.645, which is the critical value for a two tailed hypothesis test at the 10% significance level). Thus, it has been established with significant confidence that the relative productivity of an old worker (-2.45) is statistically *different* from that of a young *worker*. Thus, the weighted productivity of an old worker, evaluated at 'mean share' is

$$(\phi^{0*}_{o,ICT} X \text{ mean of share of old}) = \phi^{0*}_{o,ICT} X (\sum_{t=1}^{T} S_{o,t} / n_t)$$

, where n_t is the number of time periods. This would come out to -2.45 x 0.22, which is equal to -0.539.

<u>**Stata Table 1: STUDYING EFFECT OF OLD POPULATION ON NUMBER OF WORKERS EMPLOYED IN MANUFACTURING**</u>

```
. regress employedinmanufacturing PercentOlder yf1996 yf2001 yf2006 yf2011 LabourForce
```

Source	SS	df	MS
Model	903495.979	6	150582.663
Residual	56205.1635	14	4014.65454
Total	959701.143	20	47985.0571

Number of obs	=	21
F(6, 14)	=	37.51
Prob > F	=	0.0000
R-squared	=	0.9414
Adj R-squared	=	0.9163
Root MSE	=	63.361

employedin~g	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
PercentOlder	-109.8805	27.79435	-3.95	0.001	-169.4935	-50.26759
yf1996	14.94953	77.35609	0.19	0.850	-150.9628	180.8619
yf2001	84.96463	123.4344	0.69	0.502	-179.7758	349.705
yf2006	-75.35431	144.2932	-0.52	0.610	-384.8324	234.1238
yf2011	-87.6873	185.9862	-0.47	0.645	-486.5879	311.2133
LabourForce	.2060133	.0570034	3.61	0.003	.0837531	.3282735
_cons	1497.821	2385.758	0.63	0.540	-3619.12	6614.763

Stata Table 2: STUDYING THE EFFECT OF NUMBER EMPLOYED IN MANUFACTURING ON LOG Stata

```
. regress EmployedMfLOG EmployedManufacture yf1996 yf2001 yf2006 yf2011 LabourForce
```

Source	SS	df	MS			
				Number of obs	=	21
				F(6, 14)	=	70021.72
Model	.018288465	6	.003048077	Prob > F	=	0.0000
Residual	6.0943e-07	14	4.3530e-08	R-squared	=	1.0000
				Adj R-squared	=	1.0000
Total	.018289074	20	.000914454	Root MSE	=	.00021

EmployedMfLOG	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
EmployedManufacture	.0001395	6.05e-07	230.57	0.000	.0001382	.0001408
yf1996	.0005163	.0002406	2.15	0.050	1.59e-07	.0010323
yf2001	.0010816	.0003044	3.55	0.003	.0004287	.0017345
yf2006	.0010606	.0004228	2.51	0.025	.0001538	.0019675
yf2011	.0009776	.0005286	1.85	0.086	-.0001562	.0021114
LabourForce	6.31e-07	2.23e-07	2.82	0.014	1.51e-07	1.11e-06
_cons	7.850098	.0076708	1023.37	0.000	7.833645	7.86655

Stat Table 3: RELATIVE PRODUCTIVITIES OF LABOUR,OF ICT, AND OF THE INTERACTION BETWEEN THE TWO

```
. regress TotalOutputLOG EmployedMfLOG TotalCapitalLOG TFPIndexLOG Sh_Old_Mf ShOld_MfXsh_ICT sh_ICT LabourForc
> e mean_nominal_monthly_earnings yf1996 yf2001 yf2006 yf2011
```

Source	SS	df	MS			
				Number of obs	=	21
				F(12, 8)	=	77.30
Model	.345047048	12	.028753921	Prob > F	=	0.0000
Residual	.002975995	8	.000371999	R-squared	=	0.9914
				Adj R-squared	=	0.9786
Total	.348023043	20	.017401152	Root MSE	=	.01929

TotalOutputLOG	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
EmployedMfLOG	1.423485	1.165679	1.22	0.257	-1.264577	4.111546
TotalCapitalLOG	2.273916	.9021756	2.52	0.036	.1934953	4.354337
TFPIndexLOG	.8753158	.1640009	5.34	0.001	.497129	1.253503
Sh_Old_Mf	-2.450218	1.950085	-1.26	0.244	-6.947121	2.046686
ShOld_MfXsh_ICT	24.06155	26.14288	0.92	0.384	-36.22404	84.34713
sh_ICT	-5.26828	6.977278	-0.76	0.472	-21.35791	10.82135
LabourForce	-.0000383	.0000531	-0.72	0.491	-.0001609	.0000842
mean_nominal_monthly_earnings	.0002107	.0001802	1.17	0.276	-.0002049	.0006263
yf1996	-.0555388	.0288928	-1.92	0.091	-.1221656	.0110881
yf2001	-.087834	.0406137	-2.16	0.063	-.1814894	.0058213
yf2006	-.0865725	.053867	-1.61	0.147	-.21079	.0376449
yf2011	-.1037105	.0700922	-1.48	0.177	-.2653433	.0579224
_cons	-27.3643	15.25842	-1.79	0.111	-62.55028	7.821677

Stata Table 4: MEAN OF SHARE OF OLD WORKERS

```
. mean Sh_Old_Mf

Mean estimation                    Number of obs   =         21
```

	Mean	Std. Err.	[95% Conf.	Interval]
Sh_Old_Mf	.2272381	.0143744	.1972536	.2572226

[End of Appendix]