Distorted labor productivity!

Testing the concept of exclusion productivity

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Abstract

This paper shows that labor productivity is mismeasured, if fluctuations in the labor force are not considered. In part, the increase in labor productivity stems from the exclusion of large shares of the work force. Therefore, we propose an alternative measure of productivity that corrects for this bias. We show that exclusion productivity results from trends in unemployment rates as well as from trends in working hours. Furthermore, in line with previous research we show that export performance can be predicted by labor productivity and that considering exclusion productivity enhances the fit of econometric models, as our indicator seems to allow a more precise measurement of labor productivity.

Keywords: aggregate productivity, productivity measurement, measurement bias, exclusion productivity

JEL Classification: E01, E24, J24, O47

1 Introduction

When thinking about productivity it is common sense to define productivity as the amount of produced output by the amount of inputs. In macroeconomic terms we talk about the aggregated output of an economy or sector and the total amount of inputs, in microeconomic term the amount of output and inputs of producing one single product is meant. On a micro level also the concept of efficiency is often used. On a macro level productivity is mostly defined as the ratio between a volume

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measure of output and a volume measure of input used (OECD 2001). The idea of an aggregate production measurement goes back to the idea of Solow's production function. The work of Jorgenson/Griliches (1967) as well as Diewert (1976) gave major contributions of how to measure productivity in practice as they worked out measurements of output und inputs what we find now in growth accounting as well as the usage of index numbering.

In the literature two main distinctions of macroeconomic productivity measures can be noted, the single or partial factor productivity and the total or multifactor productivity. The partial factor productivity describes the relationship of output and one single input of the production (function) like labor, capital or human capital. The total factor productivity gives a measure of output and the combination of all input factors. The most prominent and widely used productivity concept is labor productivity. It measures the ratio of output and labor inputs, where output is either the gross domestic product or the value added. Labor input is commonly measured by the total number of hours worked which often comes from micro-census data evaluations. Sometimes labor input is measured by the number of employees (OECD 2015).

The concept and measures of labor productivity are not without any critique. Some criticize the measurements of labor input, as the true labor intensity is hard to measure by the growing fraction of part-time employed people today (ibid.). Others argue that there are differences in the quality of labor input among economies and industries (OECD 2001). Although quality adjusted labor measurements have been developed, we can only operate with aggregated and average values. A common critical point about conventional labor productivity measurements is that these are not sensitive on fluctuations of labor force. When the aggregated level of unemployment increases and the substitution effect of labor to capital is lower than the employment leaves, the level of productivity is rising automatically, as in general the more productive employees stay in their jobs. This comes from the arithmetic of the labor productivity definition. We call this effect the exlcusion productivity effect, as the exclusion of unemployment automatically generates a bias that needs to be corrected in order to obtain a more precise measurement of labor productivity. The results of our analysis show that the exclusion concept of (labor) productivity has a better fit in most applications.

The remainder of this paper is structured as follows: Section 2 clarifies the theoretical concepts. Section 3 conducts comparative empirics of both concepts, the conventional and exclusion productivity. Furthermore, an econometric investigation of applying the exclusion productivity concept is carried out in section 4. Finally, section 5 concludes.

2 Theory

2.1 Basic concept

In general, productivity gains arise, when output increases faster than input factors. There are many different types of productivity. The classical literature (see e.g. Solow 1956) distinguishes between labor productivity, capital productivity and total factor productivity, where the latter arises from technological progress and the former arise from factor accumulation. In addition, one can think of resources, materials or organizational structure as other sources of productivity. In this paper, we focus on labor productivity, where conventional measures seem to be fundamentally biased as they ignore unemployement. Thus, a part of labor productivity might result from the exclusion of unemployed from the work force. Correcting this bias should allow a more precise measurement of labor productivity.

The origins of the idea of exclusion productivity can be traced back to Hellwig/Neumann (1987). The authors mainly concentrate on capital-labor substitution and argue that wage policies that are based on inflation and productivity are only neutral along a steady-state growth path (see ibid., p.123). This changes if the economy is away from the steady state and productivity growth not only results from technological progress, but from capital-labor substitution. "To the extent that this wage policy incorporated producitivity gains from capital-labour substitution into real wages, it continuously reinforced the initial wage shock and the perceived need for further capital deepening." (Hellwig/Neumann 1987, p.124). According to an OECD estimate cited by the authors, capital-labor substitution accounted for 1 percentage point in productivity growth (see ibid., p.125). As evidence for this shift from capital widening to capital deepening, they point to the fact that the share of net investment in net national product decreased, while the share of replacement investment in current investment increased, which is a typical pattern of capital-intensive production. Accordingly, the growth rates of both output and investment slowed down due to lower share of capacity-expanding investment.

Later, Sinn (2005) estimated the productivity bias to be around 0.9 percentage points per year (see ibid., p. 113-117). His calculation considers the number of unemployed as well as the reduction of working hours (see ibid., p.116f). While unit labor costs in Western Germany have increased by 1.7% per year between 1982 and 2002, the actual increase of unit labor costs amounts to 2.6%. Calculated in this way, wages have to be around 19% to correct for the productivity bias that existed over twenty years (see ibid., p. 117).

The concept can be easily understood by looking at equations (2.1) and (2.2). Labor productivity is usually calculated as real output divided by labor input. Labor input can be decomposed into the number of employed and the number of working hours per employee.

$$\frac{Y}{L} = \frac{Y}{E \cdot H} \tag{2.1}$$

However, productivity is overestimated, if higher unemployment and lower working hours are not considered. In this case, the production is distributed on a smaller number of people and a smaller number of working hours. Therefore, we propose a different productivity measure that corrects for this bias (see equation 2.2).

$$\frac{Y}{L} = \frac{Y}{(E+U) \cdot H^*} \tag{2.2}$$

The unemployment effect is particularly a problem in times of rising structural unemployment, when seeming productivity growth increases wage costs and unemployment. If average working hours per employee fall such that $H < H^*$, a part of the potential of working hours is no longer used and productivity is again overestimated. Mathematically, the denominator shrinks for a given numerator. To obtain a more precise measure of productivity growth, both the rising unemployment and the reduction in working hours have to be considered. Alternatively, labor productivity can directly be calculated by relating output to the number of employed and unemployed. In this case, the productivity measure corrects only for the unemployment effect.

2.2 Derivation

In this subsection, the concept of exclusion productivity will be derived in a standard microeconomic setting. We assume that the individual firm i faces the following Cobb-Douglas production function, where output is produced with technology A, capital K and labor L.

$$Y_t^i = A_t^i (K_t^i)^\alpha (L_t^i)^{1-\alpha} \tag{2.3}$$

The firm maximizes profits, while taking the price as given and normalized to one. Labor costs are given by the wage w and capital costs are given by the interest rate r.

$$\pi_t^i = \underbrace{p}_{=1} Y_t^i - w_t L_t^i - r_t K_t^i \tag{2.4}$$

From this, we derive the marginal product of labor:

$$\frac{\partial \pi_t^i}{\partial L_t^i} \Rightarrow w_{1,t}^i = (1-\alpha)A_t^i \left(\frac{K_t^i}{L_t^i}\right)^{\alpha} \tag{2.5}$$

Next, we define the level of labor productivity

$$\left(\frac{Y_t^i}{L_t^i}\right)_{labor} = A_t \left(\frac{K_t^i}{L_t^i}\right)^{\alpha} \tag{2.6}$$

As can be seen, the level of productivity is part of the marginal product of labor and thus part of the wage. Labor is usually defined by equating it to the number of employed times working hours, i.e. $L_t = E_t H_t$. However, define labor as $L_t = (E_t + U_t)H_t^*$, i.e. we additionally consider unemployed persons as well as a historically observed maximum of working hours per person that determines an upper limit of potential working hours. Thus, the more precisely measured level of labor productivity that incorporates the productivity effect arising from the exclusion of U_t is given by:

$$\left(\frac{Y_t^i}{L_t^i}\right)_{excl} = A_t^i \left[\frac{K_t^i}{(E_t^i + U_t^i)H_t^{i,*}}\right]^{\alpha} \tag{2.7}$$

Plugging 2.7 into 2.5 gives:

$$w_{2,t}^i = (1-\alpha)A_t^i \left[\frac{K_t^i}{(E_t^i + U_t^i)H_t^*}\right]^{\alpha} \tag{2.8}$$

Accordingly, the wage level under 2.5 is higher than under 2.8, i.e. $w_1 > w_2$.

From this micro concept follows that aggregate productivity must also be lower:

$$Y_t = \int_0^{\infty} Y_t^i di = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{2.9}$$

Thus, the level of productivity is

$$\left(\frac{Y_t}{L_t}\right)_{labor} = A_t \left(\frac{K_t}{E_t}\right)^{\alpha} \tag{2.10}$$

while the level of productivity that corrects for the exclusion effect is given by

$$\left(\frac{Y_t}{L_t}\right)_{excl} = A_t \left(\frac{K_t}{(E_t + U_t)H_t^*}\right)^{\alpha} \tag{2.11}$$

Note that the growth rate of the right side of 2.11 is reduced by the growth rate of U_t, which means that an upward trend in unemployment rates implies an overestimation of labor productivity growth rates. This measure also corrects for changes in working hours by setting H equal to a historical value. In this case, lower working hours would imply a higher productivity.

Now let us look at the causal mechanisms that are at work. Unemployment could either result from increased supply or reduced demand. Figure 1 shows the effect of a higher labor supply. The supply curve is pushed down from S to S_1. Without wage flexibility, the wage is fixed at w_1 and thus employment will still be at L_1, while unemployment amounts to the difference $L_2 - L_1$. With lower employment, productivity is overestimated and results in higher wage costs. Most importantly, the exclusion effect is self-reinforcing and leads to an equilibrium with high unemployment and low employment. Most interestingly, a demand-side unemployment shock could have supply-side effects as the initial rise in unemployment overestimates productivity and raises wage costs thus transforming a demand side problem into a supply side problem.

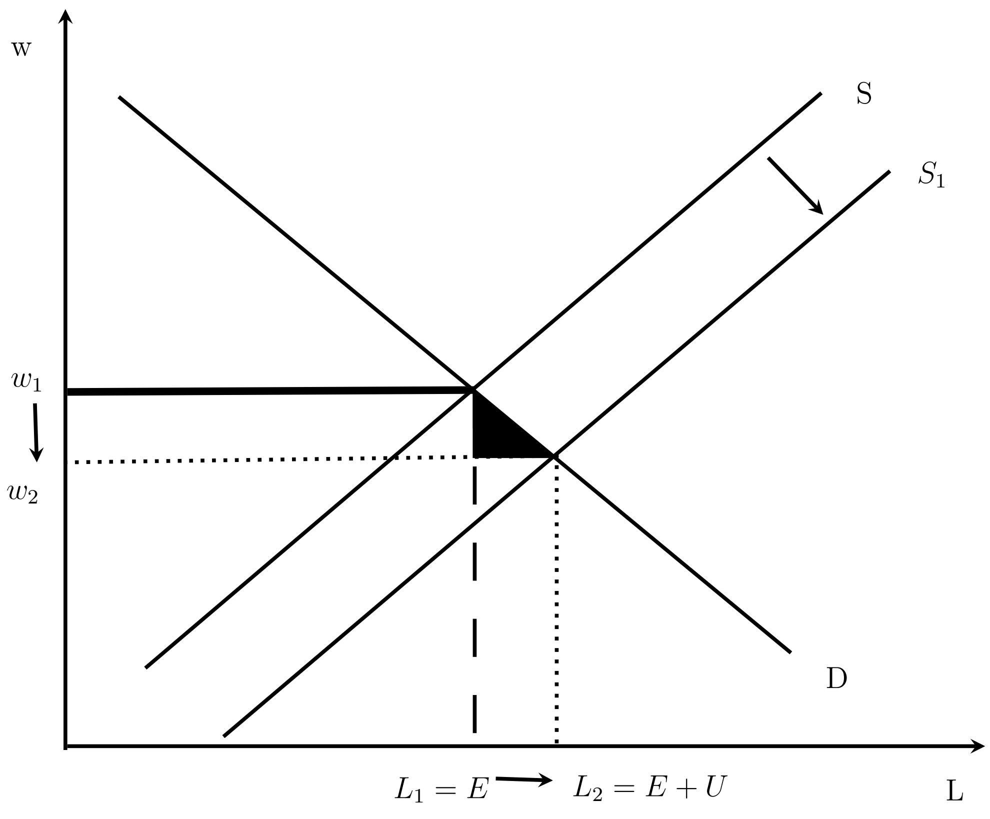

Figure 1: Wage inflexibility and unemployment

A similar exclusion effect also arises from the reduction in per capita working hours. A higher minimum wage could induce employers to reduce per capita working hours to save labor costs. This reduction indicates a higher productivity which then leads to wage increases but also reinforces the exclusion of parts of the work force. This effect has to be mentioned separately, as per capita working hours represent a distinct expression in 2.11.

Another mechanism concerns the substitution between capital and labor. Under a Cobb-Douglas technology the elasticity of substitution is constant and equal to one, which implies that a one percent change in factor prices leads to a one percent change in the ratio of factor inputs. Thus, if productivity growth is overestimated by one percent and wages increase by the same amount, the amount of capital that is used in production relative to labor increases by one percent (see Borjas 2016, p.106). If wage costs increase, this leads to a substitution process between labor and capital. Figure 2 shows the isoquant derived from the production function of a firm. Cost-minimizing firms will choose point A, where the cost curve C_1 and the isoquant Q intersect. If wage costs increase relative to capital costs, the cost curve switches to C_2 so that firms will choose point B and subsitute labor for capital. In the end, capital input will increase from K_1 to K_2, while labor input will fall from L_1 to L_2. Thus, capital-labor substitution represents a reaction to changing factor prices. This does not necessarily mean that unemployment rises, because working hours per employee could also be reduced. Capital-labor substitution constitutes a separate source of the exclusion productivity effect, as it affects simultaneously the nominator and the denominator in 2.11: it raises capital and lowers L_t (or H_t) at the same time.

In sum, the concept of exclusion productivity covers three effects:

- unemployment shocks
- reduction of per capita working hours
- capital-labor substitution

However, our measure of exclusion productivity in 2.11 does not inform us about the exact sources of the overestimation. Unemployement could be rising due to increased migration, low education efforts, capital-labor substitution induced by technological progress or caused by wage policy. Moreover, there might be an interaction of various sources. The same is true for the reduction in working hours which could e.g. stem from changing preferences or higher sick leave. Nevertheless, this overestimation of labor productivity has to be corrected, as in all cases productivity gains are distributed that do not exist thereby leading to the exclusion of large shares of the population from the world of work.

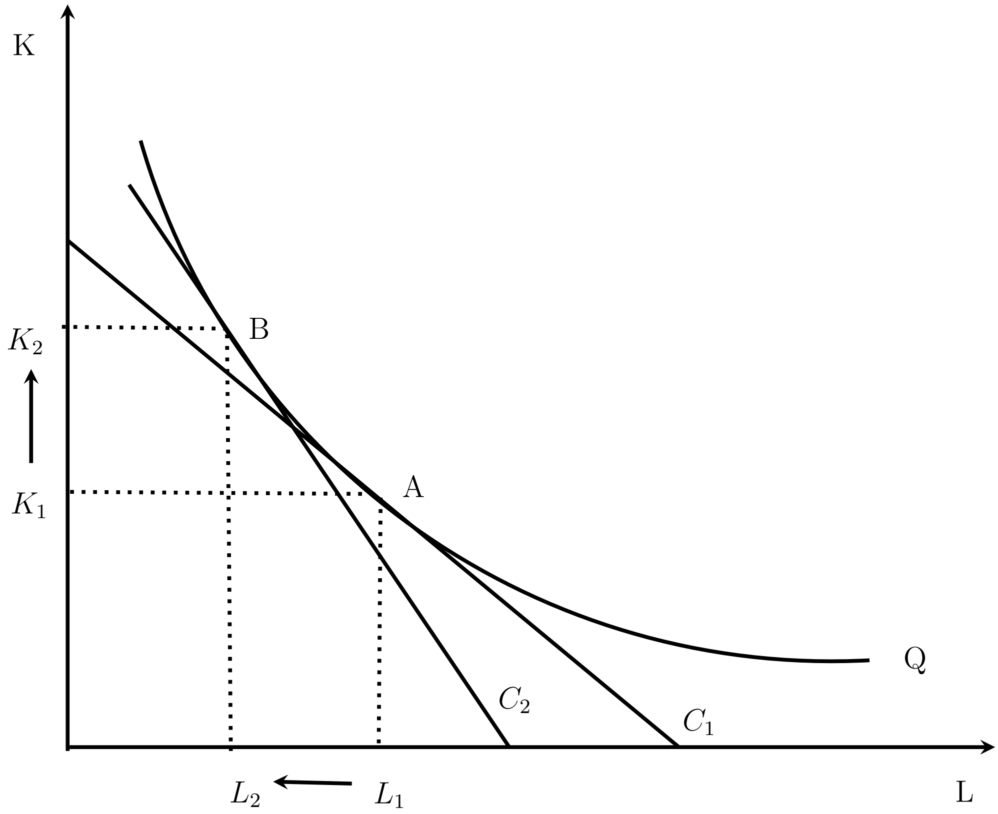

Figure 2: Factor input decision of the individual firm

	conventional productivity		exclusion productivity	
	1975-2016	1995-2016	1975-2016	1995-2016
Australia	63.3	34.8	60.0	39.2
Austria		36.4		33.7
Belgium	73.2	18.5	67.5	24.4
Canada	47.4	25.0	45.9	28.9
France	79.0	26.0	71.0	26.7
Germany	89.0	29.0	86.5	33.8
Greece		25.6		9.3
Ireland	165.1	85.5	162.4	93.5
Italy	57.2	8.5	50.3	8.0
Japan	96.6	30.9	94.8	30.7
Netherlands	41.7	21.7	41.2	23.0
New Zealand	28.6	27.8	23.2	31.3
Norway	89.0	25.5	85.7	26.4
Spain	75.2	8.4	56.3	14.6
Sweden	65.6	34.6	60.5	37.9
Switzerland		25.5		24.1
United Kingdom	80.9	29.3	78.0	34.7
United States	62.8	35.5	63.7	36.8

Table 1: Cumulative productivity growth, Source: OECD, own calculations

3 Comparative empirics of both concepts

In this section, the extent of the productivity bias related to the exclusion of parts of the workforce is investigated for major OECD economies. Therefore, the conventional measurement of labor productivity, namely output per working hour, is calculated and compared to our concept of exclusion productivity according to equation 2.1. Both types of measures can be used to calculate (cumulative) growth rates of productivity for the last decades as well as an exclusion index, which will be defined below. The data regarding real GDP, average working hours per person employed as well as employment and unemployment data can be found in the OECD databases (national account DB, productivity DB and labor force statistics).

Table 1 shows the results for the conventional labor productivity concept as well as our exclusion productivity concept for the periods 1975 to 2016 and 1995 to 2016. For Austria, Greece and Switzerland data is available only for the time period starting from 1995. The long run comparison between these two concepts shows that for most countries the labor productivity growth rates are higher in the conventional measure than in our measure. The labor productivity growth e.g. in Belgium was 73.2% for the period 1975 to 2016 according the conventional measure but only 67.5% in our calculation method. Substantial differences can also be identified for Italy 57.2% versus 50.3% or Spain with a conventional cumulative growth of 75.2% versus 56.3% in the exclusion concept for the long run period.

In contrast, there are also countries where both concepts coincide very well, with similar results and no major differences in the application of each measurement. For the period between 1975 to 2016 the cumulative labor productivity growth rate was 41.7% for the Netherlands in the conventional measure and 41.2% in the exclusion concept. The same is true for the United Kingdom with 80.9% versus 78.0% or the United States with 62.8% versus 63.7%.

The comparison of these two measurement concepts also indicates a potential over- or underestimation of labor productivity growth rates, by the assumption of the exclusion concept being a more precise productivity measure. A higher productivity growth rate in the conventional concept would indicate an overestimation of the labor productivity; a higher growth rate in the exclusion concept would indicate an underestimation of labor productivity. Empirical data show both cases are relevant for OECD countries, sometimes depending on the chosen time period.

Noteworthy is also the fact that in a first guess one could argue that a few percentage points differences in the cumulative growth rate in such a long time span does not account much, but–as one can see further below–the differences might be much higher when considering different sections of that long time period or single years that might be relevant for certain analyses.

Figure 3 shows the differences of the conventional and the exclusion measurement concept for labor productivity growth rates for the recent years graphically. For countries like the United States, Sweden, France or Italy both concepts result in similar growth rates, so there is no gap between conventional and the unbiased productivity growth. Comparing the two concepts indicates an overestimation of productivity growth for countries like Ireland, Austria, Switzerland, Netherlands as well as for Spain and obviously Greece. A potential underestimation of productivity for the recent years since 2000 can be seen for countries like Australia, Japan, New Zealand or Germany.

As mentioned before, the congruence of both concepts differs in time as well as in countries. Analyzing the potential difference between these measures, considering and generating a so-called "exclusion index" may be very useful. This index shows the difference between the conventional and our suggested exclusion concept of measuring productivity growth. An index value above 100 is therefore indicating an overestimation of productivity growth, as the growth rate under the conventional concept is higherthan under exclusion concept. Vice versa, an index value below 100 is indicating an underestimation of productivity growth. Figure 4 shows the exclusion index for selected OECD countries for the time period from 1995 to 2016.

As one can see in the graph, the productivity growth would be underestimated for Spain and Ireland during the decade of the 2000s when using the conventional

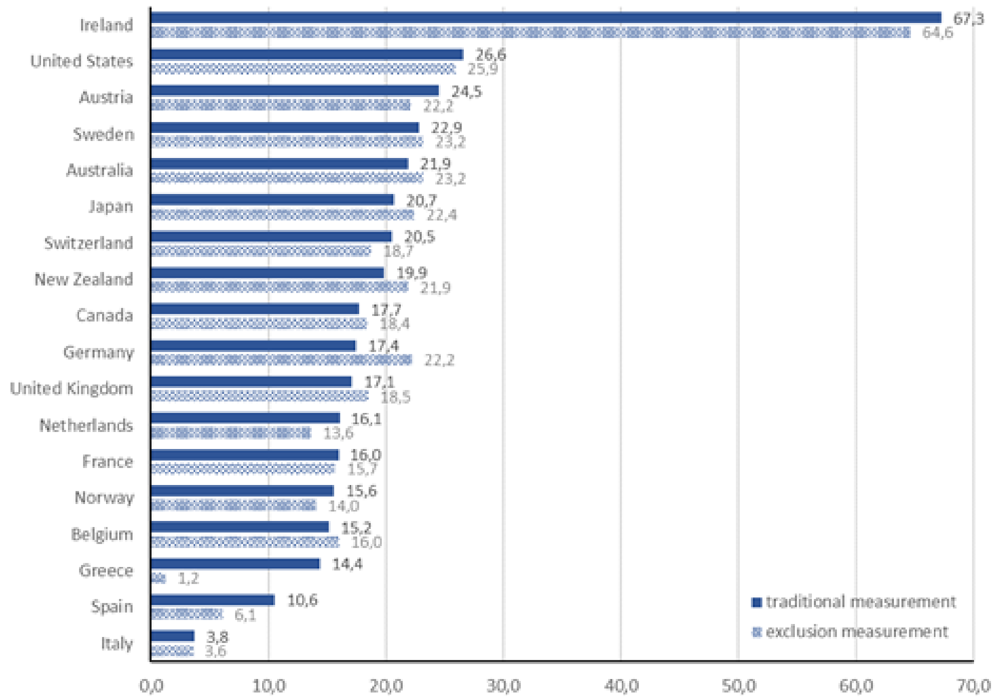

Figure 3: Comparison of productivity concepts in recent years, cumulative growth in %, 2000-2016, Source: OECD, own calculations

productivity measure. This has changed over the last couple of years, where this underestimation turned into an overestimation, at least for two years. What we can also see is that labor productivity growth of Greece is massively overestimated since the beginning of the crisis in 2008. A weak overestimation of productivity can also be seen in Austria and the United States in recent years. Since the beginning of the crisis an underestimation can be considered in the case of Germany.

Why are there differences in these two concepts and why do the results for the productivity growth rates differ over time for some countries? According equation 2.2 we would expect differences in these two measurement concepts by fluctuations in the unemployment rate. An increase in the unemployment rate has a negative effect on productivity, as the amount of potentially productive workers and employees decreased, as we have postulated in our definition. By looking at the unemployment data we found that the unemployment rate was triggered the most by unskilled unemployment in many countries. Especially for those countries with large differences between the conventional and the exclusion concept of productivity the unemployment rates of unskilled works changed substantially.

Figure 5 shows the correlation between the development of the exclusion index and the unemployment rate of unskilled (in %) for selected countries for the period

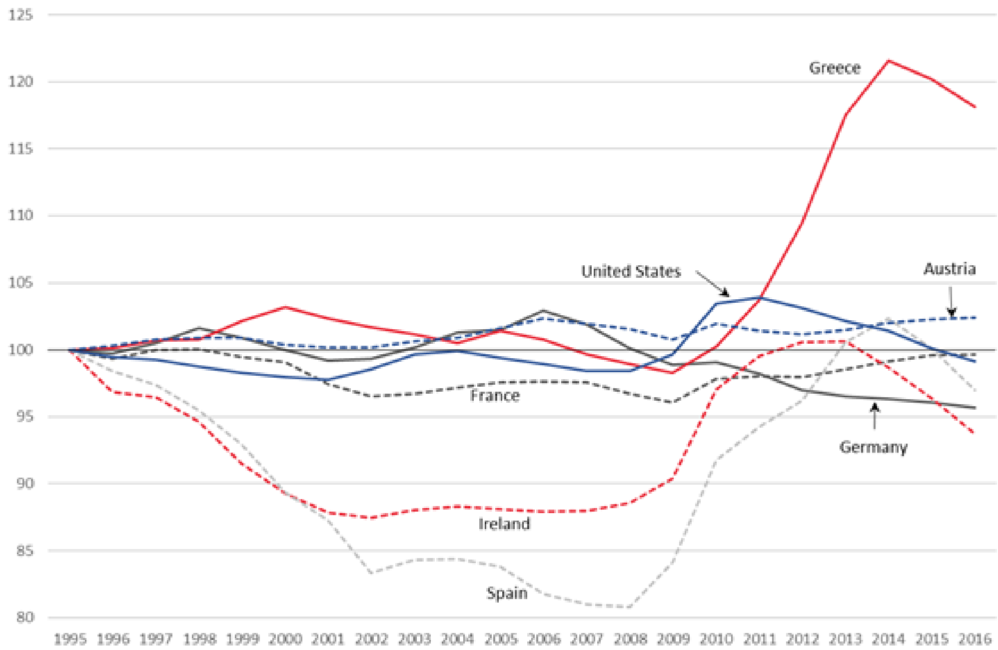

Figure 4: Exclusion-Index, Differential of conventional and exclusion concept, selected countries, 1995-2016, Source: OECD, own calculations

1995 to 2016. We can see positive correlated developments for these countries. The overestimations (underestimations) of productivity are mainly determined by increases (decreases) of unskilled unemployment rates, as the graphs show.

We argue, that labor productivity growth should be lower, if we consider that unemployment increases the denominator in the productivity formula, which leads to an increase in productivity per definition. The concept of exclusion productivity is able to correct for this effect.

To consider the effect of a reduction of working hours (per person), we have calculated the exclusion productivity also by fixing the hours worked at the level of 1975 for the sample from 1975 to 2016 and respectively at the level of 1995 for the sample from 1995 to 2016. As a result, one can see, that for those countries we have showed an overestimation of productivity growth by applying the exclusion concept of productivity measurement, the effect is getting stronger by fixing the average hours works per person. For some countries like France, Germany, Ireland or Japan the correction for working time reductions has led to an overestimation of productivity growth, at least in the period starting from 1995. All results can be found in Table 2.

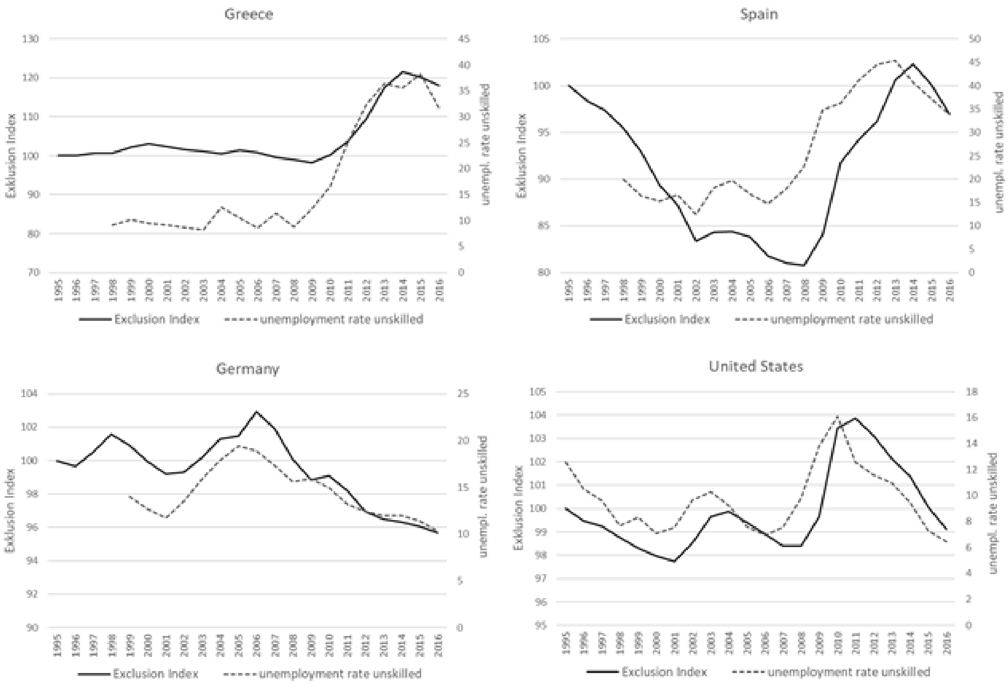

Figure 5: Correlation between exclusion index and unskilled unemployment, selected countries, 1995-2016, Source: OECD, own calculations

	conventional productivity		**exclusion productivity**	
	1975-2016	1995-2016	1975-2016	1995-2016
Australia	63.3	34.8	54.7	32.2
Austria		36.4		24.8
Belgium	73.2	18.5	52.6	23.7
Canada	47.4	25.0	35.7	24.8
France	79.0	26.0	49.2	20.4
Germany	89.0	29.0	56.4	21.8
Greece		25.6		4.4
Ireland	165.1	85.5	135.5	80.2
Italy	57.2	8.5	39.3	0.8
Japan	96.6	30.9	72.6	20.6
Netherlands	41.7	21.7	27.1	22.4
New Zealand	28.6	27.8	15.9	25.9
Norway	89.0	25.5	65.0	20.9
Spain	75.2	8.4	38.4	12.4
Sweden	65.6	34.6	60.6	37.1
Switzerland		20.2		16.7
United Kingdom	80.9	29.3	66.6	31.7
United States	62.8	35.5	60.0	34.4

Table 2: Cumulative productivity growth, hours worked fixed at level of 1975, Source: OECD, own calculations

4 Application of exclusion productivity concept

After introducing the concept of exclusion productivity, one can test how this alternative productivity measure fits or behaves in analytical applications. For that, an econometrical approach tests the fit of both concepts in a generally accepted export modelling framework.

Exploring the role and importance of productivity on export performance has quite a long tradition in foreign trade analysis. Kunst/Marin (1989) found evidence for the correlation between productivity and exports for Austrian data, Yamada (1998) found evidence for developed economies. Newer studies focused on the correlation between productivity and exports using firm level data, as the variables that explain the difference of "good exporters" compared to all the other firms are available in common firm level micro databases. Arnold/Hussinger (2004) did a firm level analysis for German Manufacturing, Wolfmayr/Christen/Pfaffermayr (2013) found evidence for Austrian service exports or Berthou et al. (2015) assessed export performance of European firms. Many of the studies in literature identified the level of productivity or the corresponding growth rates as the central determinant of export performance.

The question of the direction of causality of the correlation between productivity and exports has been answered, first by Bernard/Jensen (1999, p.1): "The evidence is quite clear on one point: good firms become exporters, both growth rates and levels of success measures are higher ex-ante for exporters". The explanation for the causal relationship of productivity on exports is in short, that firms that perform "better" increase their competitiveness against domestic and foreign competitors and can establish their products on the export markets. Firms that act or want to act in an international and export-oriented surrounding fulfil a self-selection process (self-selection hypothesis) by performing better and being more productive than the average firm (e.g. Arnold/Hussinger 2004).

The prominent focus of empirical works on firm level data (micro level) is caused by the fact, that aggregate indicators may not capture the changes or transition mechanisms of outstanding market performance (see Berthou et al. 2015). Another reason is, that there are often no good proxies that capture the heterogeneity of the micro level on an aggregate level. Nevertheless, we test the relationship of productivity and export performance at a macro level, as our productivity measure is a macro concept and from a theoretical point of view the transition mechanism must hold also on the level of countries or economies ("economies with a better performance are more competitive").

Testing the performance of the two macro productivity concepts, the strategy is as follows: In a first step we calculate the ordinary correlation coefficient between

Correlation coefficient	*Exports*
Productivity (conventional)	0,1936
Productivity (exclusion)	0,2602

Table 3: Correlation between exports and productivity (both concepts)

export performance and the productivity growth (conventional vs. exclusion) of our dataset to test the degree of the linear correlation and compare both concepts. In the second step we are testing a small export model, for each of both productivity concepts in several countries, with productivity performance of the main explanatory variable and a set of control variables as shown below. These control variables are the corresponding macro pendants of the established micro models taken from the literature above. The results and goodness of fit of both models below will be compared. The following equations are estimated

$$Exp_{it} = \beta_0 + \beta_1 LP_{it}^{conventional} + \beta_2 X_{it} + u_{it} \tag{4.1}$$

$$Exp_{it} = \beta_0 + \beta_1 LP_{it}^{exclusion} + \beta_2 X_{it} + u_{it} \tag{4.2}$$

where Exp is the export performance respectively the growth, LP is the growth in labor productivity of both concepts, X is the set of control variables, i is the subscript for the different countries and t for time.

The data we have used reflects information of sixteen OECD countries[1] from 1971 until 2017. Export data are taken from World Bank database, labor productivity data are taken from OECD database as well as from our own calculations for the exclusion concept. The set of control variables include R&D expenditures in % of GDP from OECD, expenditure on tertiary education (% of total government expenditure on education), growth in Patent applications and the real effective exchange rate, all three from the World Bank. Table 3 shows the correlation between export performance and the growth in labor productivity for both concepts.

Applying the ordinary concept of linear correlation, the productivity concept that includes the whole labor force has a stronger correlation with export performance in our dataset. That means, that the exclusion concept can explain the export performance at a higher degree, indeed it is just a two-variable comparison. Table 4 shows the regression output for the different model specifications for both productivity concepts being the main explanatory variable. Simple ordinary least square regression models have been estimated in a first stage, for productivity as the only explanatory

[1] Australia, Austria, Belgium, Canada, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom and United States.

variable in model specification (1) as well as including control variables like in specifications (2) to (5). As the data is of panel data style also fixed effects models and random effects models (panel regressions) have been estimated in a second stage. In all specifications the different model fit of conventional versus exclusion concept can be analyzed.

As the results and the corresponding adjusted R^2 show, the fixed effects models give the best fit of all estimation methods. In general, the control variables do not fit to the data very well or these macro variables do not capture different country information in a proper way. So, there are country differences in the models, that cannot be explained trough the control variables. For the purpose of explaining the macroeconomic determinants of export performance these are not highly satisfying results, as we have shown, that the micro determinants do not fit well on the aggregated level. But this is not the main focus of this work, we are just interested in the differences of the fit of our two productivity measures.

In all specifications and estimation methods, the exclusion productivity concept of including the whole labor force have the better fit for macroeconomic applications in comparison to the conventional productivity concept. The better fit is indicated by various key figures like level of significance (p-values), t-statistic of coefficient, F-statistic of the whole model fit, the adjusted R^2 as well as the information criteria of Akaike (AIC) and Bayesian/Schwarz (BIC). Robustness tests with GLM models as well as estimations of subsamples have shown similar results. The lag structures of the explanatory variables have also been tested, but this does not give any additional insight.

	conventional productivity concept					exclusion productivity concept				
OLS	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
intercept	6,601*** (0,571)	7,463*** (1,225)	11,392*** (2,142)	6,525*** (0,613)	5,300 (3,579)	6,228*** (0,539)	6,852*** (1,190)	10,465*** (2,055)	6,185*** (0,573)	3,956 (3,547)
productivity	**1,043*** (0,194)**	**0,359* (0,209)**	**0,887*** (0,217)**	**1,060*** (0,204)**	**0,408* (0,208)**	**1,317*** (0,179)**	**0,832*** (0,188)**	**1,233*** (0,201)**	**1,333*** (0,187)**	**0,858*** (0,189)**
r&d		-1,028* (0,592)					-1,076* (0,584)			
education			-0,201* (0,085)					-0,184** (0,083)		
patents				0,013 (0,050)					0,015 (0,049)	
exchange rate					0,007 (0,036)					0,014 (0,035)
adj. R^2	0,036	0,007	0,045	0,035	0,003	0,066	0,033	0,077	0,067	0,029
F-statistic	29,07	3,04	14,45	13,58	1,95	54,02	11,36	25,16	25,37	10,34
AIC	5852,34	4674,70	4532,19	5404,65	4901,52	5828,64	4658,38	4512,04	5382,25	4884,98
BIC	5866,19	4692,34	4549,62	5422,77	4919,33	5842,48	4676,02	4529,47	5400,37	4902,79
Fixed Effects	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
productivity	**1,024*** (0,207)**	**0,320 (0,223)**	**0,841*** (0,228)**	**1,025*** (0,218)**	**0,390* (0,221)**	**1,346*** (0,191)**	**0,857*** (0,200)**	**1,246*** (0,210)**	**1,350*** (0,199)**	**0,925*** (0,201)**
r&d		-3,116* (1,703)					-2,824* (1,674)			
education			-0,498*** (0,143)					-0,481*** (0,139)		
patents				0,010 (0,051)					0,013 (0,050)	
exchange rate					0,066 (0,049)					0,086* (0,049)
adj. R^2	0,334	0,218	0,344	0,323	0,238	0,355	0,240	0,368	0,346	0,259
F-statistic	20,65	9,5	16,14	17,34	10,90	22,64	10,57	17,81	19,09	12,12
AIC	5880,89	4702,73	4548,98	5433,42	4929,64	5856,15	4686,12	4527,50	5410,11	4911,27
BIC	5973,18	4795,34	4640,50	5528,54	5023,16	5948,45	4778,73	4619,01	5505,23	5004,79
Panel regression	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
intercept	6,601*** (0,571)	7,463*** (1,225)	11,392*** (2,142)	6,525*** (0,612)	5,300 (3,579)	6,228*** (0,539)	6,852*** (1,190)	10,465*** (2,055)	6,185*** (0,573)	3,956 (3,547)
productivity	**1,043*** (0,194)**	**0,359* (0,209)**	**0,887*** (0,216)**	**1,060*** (0,204)**	**0,408* (0,208)**	**1,317*** (0,179)**	**0,832*** (0,188)**	**1,233*** (0,201)**	**1,333*** (0,187)**	**0,858*** (0,189)**
r&d		-1,028* (0,592)					-1,076* (0,584)			
education			-0,201* (0,085)					-0,184** (0,083)		
patents				0,012 (0,050)					0,015 (0,049)	
exchange rate					0,007 (0,036)					0,014 (0,035)
adj. R^2	0,036	0,007	0,045	0,035	0,003	0,066	0,033	0,081	0,067	0,029
F-statistic	29,07	3,04	14,45	13,58	1,95	54,03	11,36	25,16	25,37	10,34

Table 4: Regression outputs

Coefficient of country dummies in the fixed effects model are not shown. Significance levels: * 10%, ** 5%, *** 1%

5 Conclusion

This paper has shown that labor productivity is mismeasured if it does not account for fluctuations of labor force, both with respect to the number of employees as well as with respect to per capita working hours. Our empirical results indicate substantial mismeasurement of labor productivty for many countries, while there are also economies for which both concepts coincide. Mismeasurement results from both trends in unemployment rates and working hours. Productivity can also be used as a predictor for export performance. Although there are huge country differences in explaining the export performance of countries on a macroeconomic level (shown in the fixed effects models)–that implies the omitting of additional explanatory variables–the macroeconomic productivity indicators are reliable indicators of explaining country differences in export growth. Our econometric analysis gives an indication that the exclusion productivity concept is a more precise measure of labor productivity, as the explanatory power of the models applying the exclusion concept is higher compared to the models applying the conventional concept. Further research could investigate this measure of exclusion productivity in various ways. First, one can examine the effects of exclusion productivity on wage costs and unemployment. Second, the country differences could be related to institutional differences across countries. In sum, these results should trigger a further discussion of which indicator allows to measure labor productivity more precisely at the macroeconomic level.

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