The productivity of family and hired labour in EU arable farming

Mathias Kloss¹,² and Martin Petrick¹

¹ Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany

² Chair of Statistics, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany

Contact: kloss@iamo.de

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Abstract
This paper investigates the impact of labour force composition on productivity in EU arable farming. We test the heterogeneity of family and hired labour for a set of eight EU member states. To this end, we estimate augmented production functions using FADN data for the years 2001-2008. The results reject the notion that hired labour is generally less productive than family workers. In fact, hired labour is more productive than family members in countries traditionally characterised by family farms, namely France, West Germany and Poland. Here, an increase in reliance on hired labour or the shift of family labour to more productive tasks could raise productivity. This finding calls into question a main pillar of the received family farm theory. In about half the countries, there are no statistically different effects of both types of labour. For the United Kingdom, we find the classical case with family labour being more productive than hired labour. In this situation supervision by family members could increase productivity.

Keywords
labour productivity, production function estimation, European Union, FADN

1 Introduction

According to a widely accepted view, large-scale farming operations involving many workers under a centralised management authority are economically inferior to smaller family-run businesses, at least in the temperate zones (Hayami, 2010). The two maintained hypotheses of the underlying “family farm theory” are that (1) technological scale economies are typically exhausted before farm size exceeds the labour capacity of a family and that (2) growth of the labour force beyond family members is inhibited by rising supervision costs.

However, even in agricultural regions traditionally dominated by small to medium family farm operations, such as Western Europe or the US, farm sizes have been growing and, more importantly, the share of hired workers in total labour force has been steadily increasing (Blanc et al. 2008). According to latest figures by the European Commission (2012), regularly employed non-family members on average contributed 14.7 per cent of the total agricultural workload in the EU-27 in 2010, whereas irregularly employed non-family members contributed another 7.7 per cent. This share has been on the rise for years, a fact that calls into question the validity of hypothesis (2) outlined before.

The typical argument for different productivities of these two types of labour is based on the idea that both have diverging incentives. Hired labour is usually no residual claimant and their effort cannot commonly be observed because of the idiosyncracy of agricultural production (e.g. seasonality, weather effects). Therefore, hired labourers have incentives to “shirk”. This perceived problem can be mitigated by hired labour supervision. Hence, transaction costs in the form of supervision costs arise, making farm production based on hired labour more expensive. On the other hand, however, the following argument in favour of hired labour is often overlooked: growing farms with a larger stock of workers may allow more specialisation and the division of labour into distinct tasks (Allen and Lueck, 1998). For example, family members might concentrate on management and/or supervision tasks, while hired labourers specialise in non-managerial tasks. To the extent that modern farming technologies allow such specialisation benefits, the productivity of hired labour may well exceed that of a family member who is a “jack of all trades but the master of none”.

Given these conflicting views, the present study aims to revisit the relative superiority of family over hired labour by confronting the accepted wisdom with new empirical evidence. In exploring the relative productivity of family versus hired labour, we follow, amongst others, Frisvold (1994) who investigated this question for the developing country context of India.
Here, we are primarily interested in the methodological approach of Frisvold. We follow him in using a parametric production function specification that accounts for heterogeneous labour impacts. This approach focuses on a single parameter of relative labour productivity and thus allows straightforward interpretation. Yet, our estimation technique goes beyond the received estimators used by Frisvold in tackling potential endogeneity problems. He resorted to traditional household/farm fixed effects approaches. While we also report results for such models, we focus on state of the art estimators introduced by Levinsohn and Petrin (2003) and Wooldridge (2009). Our database is a panel originating from the Farm Accountancy Data Network (FADN) of eight EU member states: Denmark, France, Germany, Italy, Poland, Slovakia, Spain, and the United Kingdom. We split Germany into East and West. Data is available for the years 2001-2008. It includes arable farms in member states with very different farm structure, both with traditional family-type farming (e.g., France and Italy) and a high share of hired labour (e.g., East Germany, Slovakia). We provide a comparison of results obtained by the received ordinary least squares (OLS) and fixed effects approaches. To our knowledge, there exist no comparable studies for EU agriculture in the area of labour force heterogeneity to date.

The results reject the notion that hired labour is generally less productive than family workers. As a most striking outcome, hired labour is more productive than family members in countries traditionally characterised by family farms, namely France, West Germany and Poland. In about half the countries, there are no statistically different effects of both types of labour. Only in the United Kingdom do we find the classical case with family labour being more productive than hired labour.

The study proceeds as follows. In section 2 we discuss the theoretical framework to measure labour heterogeneity. Section 3 briefly discusses the empirical strategy together with the estimation methods. In section 4 we present the data. Section 5 discusses the results. Section 6 concludes.

2 Theoretical framework

Suppose production can be described by the following generalised function:

\[ y_{it} = f(A_{it}, E_{it}, K_{it}, M_{it}) + \omega_{it} + \epsilon_{it}, \]  

(1)

where \( y_{it} \) the natural logarithm of output \( Y \), \( A_{it} \) is land use, \( E_{it} \) is the effective labour input, \( K_{it} \) fixed capital, \( M_{it} \) materials (working capital) and \( i \) and \( t \) are farm and time indices. \( \omega_{it} \) are farm- and time-specific factors known by the farmer but unobserved by the analyst. \( \epsilon_{it} \) are the remaining independent and identically distributed errors. Previous studies on labour force heterogeneity focused on a Cobb-Douglas functional form for (1). Therefore, we arrive at:

\[ y_{it} = \alpha^A a_{it} + \alpha^E e_{it} + \alpha^K k_{it} + \alpha^M m_{it} + \omega_{it} + \epsilon_{it}, \]  

(2)

where lower case letters denote the natural logarithm of the inputs, the \( \alpha^X \) are parameters to be estimated, and \( X \) refers to the production factors \( X \in \{ A, E, K, M \} \).

Next, we need a specification for the effective labour function \( E \). Prior research proposed several functional formsHere, we want to use the specification introduced by Frisvold (1994):

\[ E = L \left( \frac{F + \gamma}{L} \right)^{\gamma}, \]  

(3)

where \( E \) is the effective labour input in efficiency units, \( L \) is total labour time, i.e. the sum of hired and family labour time, \( F \) is family labour time, and \( \gamma \) is a parameter to be estimated measuring effective labour effort.
Figure 1. Effective labour as a function of $\gamma$.

![Figure 1](image_url)

Notes: The ratio $((F + 1)/L) \in [0, 1]$ has been set to 0.3.

Source: Authors’ elaboration.

The exponential expression in (3) has the following advantages. First, adding a ‘1’ in the numerator allows not only for farms entirely operated with family farms but also for those that solely rely on hired labour. Second, a look at this expression in (3) reveals its unique features (Figure 1). If $\gamma = 0$, family and hired labour are homogeneous inputs and thus perfect substitutes. However, if $0 < \gamma \leq 1$, effort levels of hired labour are only a fraction of those achieved by family members. Therefore, marginal productivity of family labour exceeds that of hired labour. In addition, the productivity differential increases as farm managers become more dependent on hired labour. Finally, if $\gamma < 0$ hired labour is more efficient and productive than family labour. A possible reason could be that family labour focuses too much on low productivity tasks (e.g. management, supervision) and/or that hired labour specialises in high productivity tasks. Finally, the idea of an exponential form of (3) fits well with the algebraic properties of the Cobb-Douglas function. Applying basic logarithm rules to (3) and inserting it into (2) gives:

$$y_{it} = \alpha^A a_{it} + \alpha^E l_{it} + \alpha^E \gamma r_{it} + \alpha^K k_{it} + \alpha^M m_{it} + \omega_{it} + \varepsilon_{it},$$

where $r$ and $l$ are the natural logarithm of $R = ((F + 1)/L)$ and $L$, respectively. Now, testing for labour force heterogeneity is a simple parameter test for the significance of $\gamma$.

3 Empirical implementation

Factor use across firms is usually under control of the farmer. Therefore, the inputs in (4) are subject to an endogeneity problem. As a result, the $\omega_{it}$ will likely be correlated with the other input choices. The standard OLS estimator will produce biased estimates of output elasticities as it neglects the presence of $\omega_{it}$. A typical outcome in empirical practice are upward biased elasticities for variable inputs (e.g. materials). To tackle the endogeneity problem, we need to control for $\omega_{it}$. Several methods have been proposed to solve the problem.

A first strategy is the ‘within’ or fixed effects approach. Suppose we can further decompose $\omega_{it}$ in:

$$\omega_{it} = \lambda_t + \eta_i + \nu_{it},$$

where $\lambda_t$ is a time-specific shock identical for all farms in $t$, $\eta_i$ is a farm-specific fixed effect that is constant over time, and $\nu_{it}$ is the remaining farm- and time-specific productivity shock. The usual approach then is to purge the fixed effects ($\eta_i$) by the so called within
transformation. To do so, we subtract the farm-specific means from all the variables. The \( \lambda_t \) are usually controlled for by incorporating time dummies into the model. However, the question remains whether the assumption of time constant fixed effects is plausible. Furthermore, the within transformation is known for removing too much variance from variables that exhibit little variation over time, such as land, labour and fixed capital, resulting in downward biased estimates for these factors.

Another promising strategy to production function estimation in agriculture is to use adjustment costs as identifying information (Petrick and Kloss, 2013). Assuming that \( \omega_{it} \) evolves with observed firm characteristics and given a suitable proxy we can control for \( \omega_{it} \). Levinsohn and Petrin (2003) propose materials as a candidate. If we further assume that materials is monotonically increasing in \( \omega_{it} \) and that factor adjustment is completed within one period, we can recover the production function coefficients in two stages. First, we estimate the output elasticities of land and the parameters of the effective labour function by controlling \( \omega_{it} \) with a function of materials and fixed capital. Second, we recover the output elasticities for materials and fixed capital from additional timing assumptions which are used to form appropriate orthogonality conditions. Petrick and Kloss (2013) note that this approach solves the endogeneity problem if the control function fully captures \( \omega_{it} \) and give arguments where assumptions made by the control function identification strategies are somewhat questionable.

A final issue in production function estimation is the collinearity problem (Ackerberg et al., 2007). If variable and intermediate inputs are chosen simultaneously, factor use across farms varies only with \( \omega_{it} \) which leaves output elasticities for variable inputs unidentified. One strategy to deal with this problem again refers to heterogeneous adjustment costs for different factors and is due to Wooldridge (2009). He proposes a procedure that borrows the identification strategy from Levinsohn/Petrin and modifies as well as extends the moment conditions to overcome the collinearity problem. Estimation is then conducted within an instrumental variable framework using lagged variables as instruments. In the following, we present results for an estimator set that involves the ‘within’ estimator as a benchmark, the Levinsohn/Petrin estimator and the Wooldridge (2009) modification of the latter.

4 Data

The EU’s Farm Accountancy Data Network (FADN) provides a stratified farm level data set that holds accountancy data for 25 of the 27 EU member states.\(^1\) In the present study, we only use field crop farms (TF1), to justify the assumption of a homogenous state of technology across farms. Output is measured as the total farm output in euros. The total utilized agricultural area is our land input in ha. It includes owned and rented land, and land in sharecropping. Material or working capital input is proxied by total intermediate consumption in euros. It consists of total specific costs and overheads arising from production in the accounting year. Fixed capital is approximated by using the opening valuation of assets. In this case, we took the asset value of machinery and buildings from the FADN data. In order to estimate the effective labour function (1) within a production function framework, i.e. estimating (4), we need information on hired and family labour working time separately in addition to the total labour hours. Having this data readily available in our FADN data base we can construct the additional covariate \( r \). The sample of countries is selected to reflect the diverse farm sizes and structures. The range is from small-scale family farms in Italy, Poland, Spain and West Germany to medium-sized commercial farms in Denmark, France and the UK.

\(^1\) Data has been provided within the EU’s seventh framework program research project “Factor Markets” (www.factormarkets.eu).
to large-scale and mostly corporate farms in East Germany and Slovakia (European Commission, 2012).

For every country (region in the case of Germany), we constructed a panel data set covering the years from 2001 up to 2008. The panels for Poland and Slovakia cover only five years as FADN data collection for these countries started only in 2004. Therefore, our European database consists of 35,296 observations. In order to be included in the estimating sample, farms had to be present for at least four years in a row (three years for Poland and Slovakia). Similar to Petrick and Kloss (2013), outlier analysis was performed on the basis of the fixed capital productivity per farm. Observations were excluded from the estimation if their value exceeded the median ± 1.5 the interquartile range (IQR).

5 Results

To infer about the effective labour effort parameter $\gamma$, we estimate (4) employing four estimators per country. These are 1) OLS as a baseline, 2) fixed effects regression as well as the control function approaches by 3) Levinsohn/Petrin (2003) (LP) and 4) Wooldridge (2009), hereafter Wooldridge/Levinsohn/Petrin (WLP).

The WLP estimation procedure incorporates lags up to the second order which reduces the panel length for every country by two years. For Poland and Slovakia the panel size is reduced to two years. Therefore, the WLP results for these countries should be treated with caution. Especially in the case of Slovakia an already small sample is reduced even further.

In Table 1 we report the sample size, the point estimate of $\gamma (= \delta/\alpha^{E},$ where $\delta = \alpha^{E}\gamma$). as well as its standard error per country and estimator. Our preferred estimator is the WLP estimator. On theoretical grounds, it corrects the biases induced by the endogeneity and collinearity problems present in production function estimation. Empirically, the results look very plausible. Compared to the LP estimator the differences in the parameter estimates of $\gamma$ are negligibly small for most of the countries. This, and the fact that conclusions drawn from its test of significance do not differ in all cases makes us very confident in the control function identification approach. Furthermore, the WLP estimator is occasionally more successful in identifying the capital coefficient (not shown; detailed results tables are available upon request).

Regarding the significance of $\gamma$ in the different member states and regions, the following picture unfolds. In Denmark, East Germany, Italy, Slovakia and Spain the coefficient of $\gamma$ is not significantly different from zero, i.e. hired and family labour are perfect substitutes. Generally, labour seems to be no scarce factor in Slovakia and East Germany. Both exhibit large-scale farming structures. The small- and medium scale agricultural structures of West Germany, Poland and France exhibit negative and significant $\gamma$’s. This means that hired labour is more productive than family labour but this productivity differential decreases as the farm operation increasingly relies on hired labour. It is probably here where hired labour specialises on high productivity tasks and/or family labour focuses on low productivity tasks. The size of the parameter for West Germany suggests that hired labour is much more productive than family labour. The classical case with family members being more productive than hired labour is only observed for the United Kingdom. Here, we have an argument for labour supervision. Finally, the distribution of labour force heterogeneity across the sample countries suggests that mainly small- to medium- scaled agrarian structures (with the exception of Italy) display differing effects on productivity for the two types labour.

Compared to the WLP approach, the fixed effects regression results detect labour force heterogeneity only in one case, namely Poland. A possible reason could be that after transformation too much variance was removed from the variables in the effective labour effort function. Furthermore, with regards to the OLS estimator, it seems that labour force
heterogeneity was found in too many cases. As this estimator neglects the presence of endogeneity the estimates are most likely biased. To sum up, the choice of estimator matters a lot in inferring about labour force heterogeneity.

Table 1. Effective labour effort parameter ($\gamma$) in comparison.

<table>
<thead>
<tr>
<th>Land</th>
<th>OLS</th>
<th>(\gamma)</th>
<th>SE</th>
<th>‘Within’</th>
<th>N</th>
<th>(\gamma)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td></td>
<td>0.329***</td>
<td>0.057</td>
<td></td>
<td>1027</td>
<td>0.272</td>
<td>0.220</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>-0.436***</td>
<td>0.090</td>
<td></td>
<td>6361</td>
<td>-0.649</td>
<td>0.401</td>
</tr>
<tr>
<td>Germany (East)</td>
<td></td>
<td>0.491</td>
<td>0.441</td>
<td></td>
<td>1740</td>
<td>-4.828</td>
<td>17.709</td>
</tr>
<tr>
<td>Germany (West)</td>
<td></td>
<td>-1.370***</td>
<td>0.264</td>
<td></td>
<td>3603</td>
<td>-3.955</td>
<td>4.434</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>-0.393***</td>
<td>0.113</td>
<td></td>
<td>6415</td>
<td>-0.369</td>
<td>0.395</td>
</tr>
<tr>
<td>Poland</td>
<td></td>
<td>0.002</td>
<td>0.049</td>
<td></td>
<td>5635</td>
<td>-0.931*</td>
<td>0.541</td>
</tr>
<tr>
<td>Slovakia</td>
<td></td>
<td>0.237**</td>
<td>0.111</td>
<td></td>
<td>202</td>
<td>0.861</td>
<td>0.634</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td>-0.024</td>
<td>0.016</td>
<td></td>
<td>9317</td>
<td>-0.074</td>
<td>0.060</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td>0.175***</td>
<td>0.040</td>
<td></td>
<td>996</td>
<td>0.111</td>
<td>0.165</td>
</tr>
</tbody>
</table>

Table 3 continued.

<table>
<thead>
<tr>
<th>Land</th>
<th>Levinsohn/Petrin</th>
<th>Wooldridge/Levinsohn/Petrin</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>(\gamma)</td>
<td>SE</td>
</tr>
<tr>
<td>Denmark</td>
<td>1027</td>
<td>0.145</td>
</tr>
<tr>
<td>France</td>
<td>6361</td>
<td>-0.411***</td>
</tr>
<tr>
<td>Germany (East)</td>
<td>1740</td>
<td>0.240</td>
</tr>
<tr>
<td>Germany (West)</td>
<td>3603</td>
<td>-1.322***</td>
</tr>
<tr>
<td>Italy</td>
<td>6415</td>
<td>-0.379</td>
</tr>
<tr>
<td>Poland</td>
<td>5635</td>
<td>-0.292***</td>
</tr>
<tr>
<td>Slovakia</td>
<td>202</td>
<td>1.150</td>
</tr>
<tr>
<td>Spain</td>
<td>9317</td>
<td>-0.033</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>996</td>
<td>0.203***</td>
</tr>
</tbody>
</table>

Notes: Year dummies included in all models. *** (**, *) significant at the 1% (5%, 10%) level.
Source: Authors.

6 Conclusions

In this study we assessed the heterogeneity of family and hired labour in European agriculture. Contrary to the received wisdom, we find that hired labour is more productive than family labour in the small- and medium-scale agrarian structures of France, West Germany and Poland. According to our estimates, hired labour performs the high productivity tasks in these countries. In such a situation, an increase in reliance on hired labour or the shift of family labour to more productive tasks could raise productivity. In the majority of countries we found no evidence for labour force heterogeneity. Amongst the countries in this group are also large-scale farming structures such as East Germany and Slovakia. For the United Kingdom, we observe that family labour exhibits a higher marginal productivity than hired labour. In this case, supervision by family members could increase productivity. We regard it an interesting question for future research to find out why hired labour in arable
farming is so productive in France, West Germany and Poland, three countries traditionally characterised by family farms. Farming in the UK, on the other hand, traditionally displays higher levels of hired labour. This pool of workers may to a larger extent consist of lower qualified personnel subject to the classical incentive problems.

The results have implications for future theoretical and empirical work. Most importantly, our results call into question the general validity of one of the received family farm theory’s main pillars, i.e. the dominant effect of supervision costs on hired labour productivity. Countries regarded as traditional strongholds of the family farm have apparently crossed a technological threshold where specialisation of hired labour overcompensates the negative effects of workers’ moral hazard. Factors such as the increasing importance of non-traditional and non-agricultural sources of farm household income are likely reinforcing this trend.

In classical production function estimation, labour input is measured as the sum of both, hired and family workers. Given the evidence on labour force heterogeneity in some countries with different effects on productivity, they should be included as separate inputs. Finally, this work is also a plea for refined methods that control for the problems in production function estimation. Endogeneity and collinearity problems potentially lead to wrong inference. The very similar results that we obtained from the Levisohn/Petrin and Wooldridge/Levinsohn/Petrin approaches seem to strengthen their validity on empirical grounds, besides being plausible in the theoretical domain.

References