The Effect of Intangible Assets on Value Added: Evidence from microdata across small and large firms in Europe

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May 2020

Abstract

Intangible assets have been growing at a faster pace over the past decade compared with tangible assets. Therefore, it is important to understand the role of intangible assets at a firm level. This paper uses the AMADEUS database to measure the impact of intangible assets across 32,634 firms in 7 European countries. The European Union is used as a case study as its economy is primarily composed of small and medium sized enterprises. The paper uses the approach developed by Ackerberg, Caves and Frazer (2015) to test estimate the production functions. The analysis shows that there is a difference in the impact of intangible assets relative to firm size on value added. The overall positive effect is higher for small and medium sized firms than large and very large firms.

* I would like to thank Professor Thibault Fally for invaluable advice and guidance. I would also like to thank my friend, Sameer Saptarshi, who helped me process the data.

Section 1 - Introduction

Intangible assets distinguish themselves from physical assets like capital, inventory, financial assets, or land. They include intellectual property such as patents, trademarks and computerised information. Intangible assets are more important for firms in today's economy than they have been in the past because investment in intangible assets has been increasing at a faster pace than tangible assets. To a firm, intangible assets represent sunk costs, spill overs and synergies – their value fluctuates based on how they are paired with other assets. (Haskel and Westlake 2018)

The subject of intangible assets is constantly explored by economists today to help explain the changes in the economy's structure as we shift to a more technologically driven economy. The majority of research on intangible assets focuses mainly on their impact on macroeconomic outcomes such as economic growth and unemployment. There are gaps in the literature on the role that intangible assets play at the firm level. Conducting research looking at the firm level impact of intangible assets is important in helping firms understand their potential value. There are differences in both intangible assets and overall performance across firms and it is important to understand whether intangible assets play a causal role in explaining growth in value added.

Research has shown that investment in intangible assets outpaced tangible assets around the time of the Financial Crisis. During the Financial Crisis, labour intensive services became more expensive, technology increased investment opportunities and there was a more noticeable shift from goods to services, all of which are more reliant on intangible assets. (Haskel and Westlake 2018). Now, we understand why the shift occurred, but it is important to understand the implications of this shift at the microeconomic level as it could help inform competition policy, tax amortisation laws, policy reform, etc.

Successful firms have to exceed industry trends in productivity and growth, or they will be pushed out of the market. Intangible assets can play a central role in contributing to a firm's growth. Larger firms have more expansive capabilities, so can more easily invest in intangible assets benefitting from synergies and potentially gain more market share. On the other hand, smaller firms are less likely to invest in intangible assets either due to a lack of information or lack of funds. They are unable to take advantage of intangible assets to order to effectively compete with larger firms in their industry. (National Research Council 2009)

The composition of European economies is skewed towards services and given that service industries are highly intensive in intangible assets, the contributions to growth due to intangible assets becomes more evident.(Corrado, Haskel, and Jona-Lasinio 2017)Their contribution at various levels of the value chain mean that there are potential implications for EU competition policy and changes in access to finance.

All firms, small or large, need to take advantage of investing in intangible assets because it contributes to increases in productivity and growth. Intangible assets have contributed at a macroeconomic level to greater economic growth in both the EU and the US (Corrado et al. 2018) The research question I plan to explore is how do intangible assets impact different sized firm, differently. This paper investigates the relationship between intangible assets and value added exploring the hypothesis that intangible assets impact value added differently depending on the size of the firm - small and medium sized enterprises (SMEs) compared with large and very large enterprises (LVLEs).

For the purpose of this paper, intangible asset value at firm level will be measured for a 9-year period looking at firms in the European Union. The European Union is a good case study to use as the bulk of economies are primarily made up of small and medium sized enterprises, so it is important to carry out a firm level comparison with large and very large enterprises to measure the difference in impact. One of the major limitations of intangible assets as mentioned is the inconsistencies with reporting on the balance sheet unlike with tangible assets. The European Union is working on improving the classification, access, reporting and knowledge of intangible assets to help realise their potential in the future. (Andersson and Saiz 2018)

The production function is estimated using the Ackerberg, Caves and Frazer (2015) approach because the OLS estimation will not take into account the unobserved correlations in the error term leading to inaccurate coefficients. The approach used takes into account the simultaneity bias associated with intangible assets and productivity growth. (Corrado, Haskel, and Jona-Lasinio 2017) The approach deals with this bias by estimating the coefficients in the second stage of the estimation using a dynamic model to take into the associated biases.

The hypothesis explores the different impact intangible assets have on value added depending on the size of the firm. Large and very large enterprises are expected to invest more in general compared with small and medium sized enterprises because of their greater size and reach.

However, the results of this paper, the coefficient of intangible assets for small and medium enterprises was greater than the coefficient of intangible assets of large and very large enterprises.

My paper is outlined as follows: Section 2 consists of a discussion of the characteristics of intangible assets by highlighting their importance to firms. Section 3 is a literature review looking at past research on intangible assets at both macroeconomic and microeconomic levels not just in the European Union but across the world. Section 4 is an overview of the data collection methods coupled with a brief discussion about the associated biases. Section 5 covers the theoretical and econometric foundations using the model developed by Ackerberg, Caves and Frazer. Section 6 is the analysis of results and the robustness checks. Finally, section 7 concludes the paper.

Section 2 – Characteristics of Intangible Assets

Understanding why intangible assets are important requires an understanding of the characteristics which make them important. In this section of the paper, I will briefly go over these characteristics and summarise the macro and micro level impact. The main characteristics of intangible assets are grouped into three categories: effects on competition, synergies with other assets (tangible assets) and uncertainty and sunk costs. (Haskel and Westlake 2018)

One feature of intangible assets is intellectual property which can be excludable due to proprietary information. Firms invest a significant proportion of money in developing certain technologies which if not properly protected by patents can be used by other firms, thereby eroding the initial investment and future profits (Thum-Thysen et al. 2017). If a firm invests in intangibles that would erode costs, providing economies of scale potentially leading to more intense competition. Furthermore, if other firms see their competitors benefitting from investing in intangible assets, thus creating positive externalities stimulating investment and increasing competition. Intangible assets have a two-fold effect on competition, but whether the market moves towards a more perfectly competitive market or a more monopolistic market depends on the behaviour of the firms and the industry.

Investing in intangible assets can be a risk for firms, as there is uncertainty of whether the investment will pan out. There may be high sunk costs due to experimentation, which some firms may be unwilling to risk especially if firms are willing to invest in tangible assets. (Thum-Thysen et al. 2017) Intangible assets have synergies and complementarities with other types of assets in particular – tangible assets. For example, developing a new technology would require investment in capital (tangible assets) and its success could depend on the quality of the goods used. (Thum-Thysen et al. 2017)

The literature suggests that investment in intangible assets is more productive when companies are directly affected by the incentives and the positive externalities that arise from the various characteristics. At the macroeconomic level, the effects are seen in terms of economic growth and total factor productivity. At the microeconomic level, the effects are seen productivity, innovation and spending on research and development.(Thum-Thysen et al. 2017)

Section 3 – Literature Review[1]

The majority of papers focused on either the measurement of intangible assets or their macroeconomic contributions to growth. There is vast literature on accounting and the measurement of intangible assets. Firms do not always properly report intangible assets on their balance sheet. For the purpose of this paper, this means that there would potentially be inconsistencies due to misreporting.(Amico 2012)

In terms of research carried out at a firm level, the majority analysed the impact on factors such as productivity and efficiency, making comparisons to tangible assets. There has also been cross country analyses between the European Union and the United States focusing on the contribution to productivity growth. Corrado et al. (2018) concludes a positive correlation with faster growth in the US. Based on these research findings, small and medium sized enterprises need to invest in intangible assets regardless of the type of industry, to compete with large enterprises, due to the more significant positive gains.

Ark et al. (2009) conducted research on measuring intangible asset investment and compared them to eleven advanced economies in the European Union. The study focused on the impact

[1] When conducting my research for the literature review, I looked at *EconLit* and *Semantic Scholar* to find relevant papers that would not only help me contextualise my paper, but also see what other studies have already been researched. To filter the results, I used key terminology such as *intangible assets, SMEs, EU* and *firms* in the title. In conducting my research, I used both a forward and backward approach. After finding the papers, I read the abstracts and introduction. If they were pertinent to my research, I skimmed the rest of the paper, looking at the tables and the methodology to see how it could be applied to my future work. I also looked through the reference sections and the literature reviews to extend my research when applicable

at a macroeconomic level looking at economic growth in high-wage economies. The paper carried out a time series analysis on the composition of intangible assets over ten years. It also used a growth accounting framework to combine the measures of intangible assets across countries. This paper is useful in understanding how to make comparisons between countries, which shows a positive correlation between the variables (intangible assets and labour productivity).

Ng, Mui, and Kee (2012) carried out research exploring the role of intangible assets on the productivity and competitiveness of small and medium sized enterprises in Malaysia. It highlights the growing importance of intangible assets compared with tangible assets in the industry. While this paper did not have an empirical study on Malaysian small and medium sized enterprises, it gave me a good foundation for the rest of my literature review because it listed numerous studies/researches conducted on different aspects of assets on measuring business success. This was a relevant paper, but it was not as effective in seeing if my conclusion would be predictable as it was a theoretical compilation of several studies. Unlike my paper, which will consist of regressions analysing SMEs, there was no econometric analysis; however, it helped contextualise further research.

Kapelko (2009) focused on intangible assets in the textile and apparel industry and its role in firm efficiency. The methodology was useful in helping me understand how to separate firm identification, which has implications for future research which will take into account specific industry differences. Furthermore, the study focused on the role of assets in a less high-tech industry where intangible assets play a more significant role. The conclusion reached in this paper is supports the premise that firms need to invest in intangible assets regardless of industry.

Bontempi and Mairesse (2015) ran an econometric analysis focusing on the productivity of different types of intangible assets such as intellectual capital (R&D/patents) and customer capital (trademarks/advertising). Their results show the value of intangible assets is higher than what can be predicted using the individual firm data. This study has implications for my paper as my data sample uses firm balance sheets, so according to this paper’s findings, the regression will have some degree of omitted variable bias, which I would need to take into account.

Nunes and Almeida (2009) conclude a quadratic relationship between intangibles assets in Portuguese small and medium sized enterprises and growth, which is not supportive of my conclusions as this means that its impact is dependent on the level of intangible assets (positive for high levels and negative for low levels). The study classifies small and medium sized enterprises using three categories (number of employees, assets, and business volume); however, in my paper, I will only be classifying small and medium sized enterprises by the number of employees. This study, while similar, differs from mine as I will be comparing small and medium sized enterprises to large and very large enterprises and not on the level of intangible assets/size of the previous period.

Capitalism without Capital (Haskel and Westlake, 2018) did not yield much econometric analysis or methodologies, but was incredibly useful in helping to discern the economic implications between intangible assets and its contributions at the firm-level. It mainly focused on data at the macro level of the United States and the European Union. They highlight the shift and its reasons from tangible investment to intangible investment. They also recognise how the structure of the economy and the policies put in place need to evolve, so that a solid foundation can be built to take advantage of the opportunities. They also note the difficulties that policymakers face in building this foundation. These problems included developing a framework for intellectual property, structure of financial markets, increasing social and economic inequality and conditions for research and development.

The literature was expansive, but the aforementioned papers provided the most impact to my research and the development of this paper, methodology and hypothesis. The literature summarily concludes that the impact of intangible assets is positive at a macroeconomic level and a microeconomic level. The evaluation of intangible assets is primarily focused on macroeconomic factors, so it is important to understand what occurs at a microeconomic level.

The conclusions summarise the importance of intangible assets has increased over the past decades and its continual growth means that investment by firms is important at all levels. While there was literature conducted by individual countries on the impact of intangibles on small and medium sized enterprises, I found that there was an opportunity to research intangible assets comparing small and medium sized enterprises and large and very large enterprises in the wider context of the European Union.

Section 4 –Theoretical and Econometric Foundations

In this section, I will explore the theoretical foundations used to measure the impact of intangible assets on value added. Previous research using firm level data found biases due to synergies between the variables, leading to an issue with endogenous variables. An OLS regression is not sufficient and leads to biases, as there are correlations between intangible assets and tangible assets as well as other factors that may be present in the error term. Hence, we run into issues with selection and omitted variable bias.

The data consists of firms (i) over a time period (t) which is between 2011 and 2019. A firm's inputs are given by ($K_{it}, X_{it}, L_{it}, M_{it}$) and the log values are given by ($k_{it}, x_{it}, l_{it}, m_{it}$) which represent tangible assets(K), intangible assets(X), labour(L) and materials(M) respectively. Log values need to be used the theoretical foundations of the paper are based on the Cobb-Douglas model. The standard econometric model is based on the work of Ackerberg, Fazer and Caves (2015) who developed an approach to deal with biases arising from firm-level data building on previous research carried out by Olley and Pakes (1996) and Levinsohn and Petrin (2003). The methodology devises a two-stage estimation to estimate the coefficients for the specified inputs.

The model's general equation is:

$$y = \beta_l l_{it} + \beta_k k_{it} + \beta_x x_{ix} + \beta_m m_{ix} + \beta_0 + \zeta_{it}$$

It is estimated either for three different samples: all firms (full sample); small and medium sized enterprises (SMEs) and large and very large enterprises (LVLEs)

We adopt a standard Cobb-Douglas production function:

$$Y = F(A_{it}, K_{it}, X_{it}, L_{it}, M_{it}) = A_{it} K_{it}^{\beta_k} X_{it}^{\beta_X} L_{it}^{\beta_L} M_{it}^{\beta_M}$$

where Y_{it} denotes firm i's value added, X_{it} denotes intangible asset input (measured as a value of a firm's intangible assets at a given time), K_{it} denotes tangible assets output, L_{it} denotes the size of the firm (measured by the number of employees – explained more in the methodology section) and materials M_{it} denotes the materials which will be calculated as the difference between sales and value added. A_{it} is a measure of the firm's efficiency which cannot be estimated using the available data. β_K, β_L, β_X, β_M denote the elasticity with respect to factor inputs.

For the purpose of this paper, the key coefficient I am interested in is $\beta_x$as it will help me prove the validity of my hypothesis. The common coefficient will be estimated for all firms and then the coefficient will be estimated as the size of the firm varies i.e. small/medium and large/very large.

In log, the empirical equation for the standard Cobb-Douglas becomes:

$$y = \beta_L l_{it} + \beta_k k_{it} + \beta_x x_{ix} + \beta_m m_{ix} + \beta_0 + \zeta_{it}$$

$$\zeta_{it} = \omega_{it} + \epsilon_{it}$$

In this equation, $\log A_{it}$ is decomposed in two terms β_0(mean efficiency) and ζ_{jt}deviations from the mean – factors that affect output other than intangible assets. Simply regressing value added on each input to estimate the β coefficients using OLS would be naïve, as the approach would be biased. An OLS specification is biased as firm decisions to choose their inputs for tangible/intangible assets would depend on unobservable factors in ζ_{it}, violating the OLS assumption that the inputs should be uncorrelated with the error term. Hence, the estimated coefficients of β will be biased due to simultaneity issues. (Ackerberg, Caves, and Frazer, 2015.)

ζ_{it} has two components: ω_{it} unobservable to the firm when making decisions but may be predicted and ϵ_{it} unobservable to the firm when making decisions (no information). These unobservable components are what leads to the endogeneity problem. Decisions to hire more workers (L), buy more capital (K and X) depend on productivity ω and thus these variables are correlated with the error term. Due to this correlation, OLS leads to biased estimates caused by the endogeneity between the inputs. (Ackerberg, Caves, and Frazer, 2015) If firms invest in intangible inputs due to increased growth, this would lead to a large coefficient under OLS for intangible assets – even if the contribution was not from intangible assets.

(Olley and Pakes 1996) developed a model to control for unobservable productivity shocks using proxy variables for investment and looked the implications of selection and simultaneity bias. (Levinsohn and Petrin 2003) proposed a different approach using intermediate inputs in order to resolve the simultaneity bias building on the work of Olley and Pakes. The approach developed by Ackerberg, Caves and Frazer is based on models by Olley and Pakes (1996) and Levinsohn and Petrin (2003) addresses the endogeneity issue by making more assumptions and estimating the coefficients in the second stage.

Let us now be more precise in how these inputs are chosen by firms:

- For the two types of capital, we can assume that they are functions of lagged capital and lagged investments
- Labour at time t is chosen between periods t-1 and t,
- Materials are chosen at time t, as a function of other inputs and productivity at time t. Moreover, we assume (as in Ackerberg, Caves and Frazer 2015) that materials are strictly monotonically increasing with productivity (for a given level of capital and labour uses).

To eliminate omitted variable bias that would arise in a traditional regression, tangible and intangible assets will be considered as dynamic inputs, but labour and materials are non-dynamic variable inputs. The variable 'm_t' (materials) is chosen as a function of the dynamic variables x_{it}, k_{it} intangible and tangible assets respectively.

$$m_t = f_t(\omega_{it}, k_{it}, x_{it}, l_{it}, m_{it})$$

A non-dynamic input is one that current value has no effect on its future value. In this model, the non-dynamic inputs include labour and materials. The dynamic inputs in this model are intangible/tangible assets. A variable is a dynamic input if their current value affects their value in the future. The timing of the input also matters for instance if the input is consumed in the same time period (labour/materials) or an earlier time period (tangible/intangible assets). (Manjón and Mañez 2016) The proxy variable is the unobservable variable which according to the ACF model is captured by the ω_{it}.

We can invert the function to formulate the productivity shock as a set of observable values thus we are able to find an approximation for ω_{it}. The function can be inverted due to monotonicity. Inverting the function with respect to m_t and use the other variables as control variables allows me to obtain an approximation of ω_{it}.

$$\omega_{it} = f_t^{-1}(x_t, k_t, l_t, m_t)$$

When we substitute this term into the function we get:

$$y_{it} = \beta_l x_{it} + \beta_k k + \beta_x l_{ix} + \beta_m m_{im} + \beta_0 + f_t^{-1}(x_t, k_t, l_t, m_t) + \epsilon_{it}$$

$f_t^{-1}$is treated non-parametrically thus the first three terms can be estimated through an OLS approximation and is given by

$$\phi_t(x_{it}, k_{it}, l_{it}, m_{it}) = \beta_x x_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_0 + \omega_{it}$$

This approximation gives us the first stage condition

$$E[\epsilon_{it} \mid X_{it}] = E[y_{it} - \phi_t(x_t, k_t, l_t, m_t) \mid X_{it}]$$

An issue of the first stage estimation equation is that it implies that collinearity, so we are not able to estimate $ß_l$ in this condition. The first stage of this model does not yield any estimates but is important as it differentiates between the two components ω_{it} and ϵ_{it} (Ackerberg, Caves, and Frazer 2015)

This is why the coefficients are estimated in the second stage of the model.

$$\begin{aligned} E[\zeta_{it} + \epsilon_{it} \mid X_{it-1}] \\ &= E[y_{it} - \beta_0 - \beta_l x_{it} - \beta_k k_{it} - \beta_k l_{it} - \beta_m m_{it} \\ &- \rho(\phi_{t-1}(x_{it-1}, k_{it-1}, l_{t-1}, m_{t-1}) - \beta_0 - \beta_l x_{it-1} - \beta_k K_{it-1} \mid X_{it-1}] \end{aligned}$$

ϕ_{t-1}represents an estimate from the first stage condition. This term is identified regardless of the proxy/output variables – materials/value added. This result differentiates firm's productivity, ω_{it}, from the conditional expectation at t-1 and the deviation from the expectation. (Ackerberg, Caves, and Frazer 2015)

For times beyond the time at t -1 and given the assumption that intangible assets have a year lag (i.e. have a noticeable effect on value added at t+1). The model used to find the estimates

$$E\big[y_{it} - \beta_0 - \beta_I I_{it} - \beta_k K_{it} - \rho(\phi_{t-1}(i_{it-1}, k_{it-1}, x_{t-1}, m_{t-1}) - \beta_0 - \beta_I I_{it-1})\big) \otimes \\ (1, l_{it}, x_{it}, l_{it-1}, k_{it-1,} m_{it-1}, \phi_{t-1}(l_{it-1}, k_{it-1}, x_{t-1}, m_{t-1}))] = 0$$

We need make sure that the error term is not capturing productivity, so it needs to be minimised to make sure that it is not correlated with productivity. $\phi_t$needs to be chosen to predict a measure for value added making sure that the difference is not correlated at t-1. (Ackerberg, Caves, and Frazer 2015)

This leads to the second-stage equation which will estimate the coefficients for $\beta_x, \beta_k, \beta_l$. The coefficient for β_m will not be estimated as it is the proxy variable. (Ackerberg, Caves, and Frazer 2015)

$$y_{it} = \beta_x x_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_0 + \rho(\phi_{t-1} - \beta_x x_{it-1} - \beta_k k_{it-1} - \beta_l l_{it-1} - \beta_m m_{it-1} - \beta_0) + \epsilon_{it}$$

My research question investigates the difference in impact of intangible assets at the firm level for small and medium sized enterprises (0-249 employees) and large and very large enterprises (≥250 employees). ('What Is an SME?' 2016) It is important to measure difference in impact in terms of size as the European economy is primarily composed of small and medium sized enterprises, who are not wholly aware of the positive externalities associated with intangible assets. The model described above is applicable to both small and medium sized enterprises and large and very large enterprises, therefore it will be run in STATA, in three different ways - all firms, small and medium sized enterprises and large and very large enterprises – to measure the impact on the coefficient of β_x.

Section 5 – Data Collection

This section of the paper analyses how the data was selected for the initial data sample using the AMADEUS database. The next part of the section discusses the biases arising from the sample – namely selection and simultaneity biases. The section then looks at the how the data is transformed in STATA and finally, ends with how the data sample for the robustness check was selected using AMADEUS.

Section 5.1 Data Selection

This paper uses a data sample obtained by using the AMADEUS database. AMADEUS consists of firm-level data for European firms. The AMADEUS database only guaranteed reported values from 2015-2019 not the entire 2011-2019. Therefore, the model was run using the entire and shortened time frame.

The variables are all measured in thousands of euros except for number of employees. The database does not have a recorded number for materials, but it has values for sales and value added, thus the value for materials is calculated as the difference between sales and value added. The parameters used to filter the data are:

- Only active companies in the EU15
- Reported value for value added
- Reported value for intangible assets
- Reported value for sales
- Reported value for number of employees

To select the data, I ran these parameters for each country in the European Union 15 (EU 15). I choose the EU 15 as a sample as it would be representative composition of the different economies making up the European Union. Furthermore, limiting the number of countries made the sample and the model more manageable. The United Kingdom was included as during the selected time frame (2011-2019), the United Kingdom had yet to leave the European Union. After running the parameters for each country, firms were selected from the countries excluding – Netherlands, Denmark, Greece and the United Kingdom. These four countries did not have reported values for the selection criteria. For instance, the United Kingdom was excluded as there were incomplete values for 'sales.'

Using the data for value added and sales, I calculated a value for materials. The value for materials is important in running the economic model described in the section above. The data was then converted from time-series data to panel data. Initially the sample had data for all the firms in the EU15 excluding the four countries mentioned above. Knowing that an incomplete data sample would not only lead to inaccurate values for the coefficients but also an unrepresentative sample, I dropped the firms with incomplete values reducing the number of firms and the number of countries.

After refining the initial data sample, the number of firms reduced to only firms with reported values across the time period, equating to 32,634. From the 11 remaining countries, the sample was reduced to Belgium, France, Germany, Italy, Portugal, Spain and Sweden. In this paper, these countries will be referred to as the EU7.

Section 5.2 Selection and Simultaneity Bias

With these criteria, the number of companies decreases significantly, which leads to selection bias. Selection bias occurs as the reduced selection of firms used in the study leads to a different result that if the entire sample of firms was included. There is also an issue with the simultaneity problem generated by the relationship between intangible assets and productivity growth (Olley and Pakes 1996). Corrado et. al (2017) found evidence of productivity spill overs to increases in intangible capital and skills. Using a dynamic model specifying when input decisions are made, takes these biases into account.

As seen in the literature, there is a synergy between the two assets classes (Haskel and Westlake 2018).The interaction between them yields a greater effect than should they be invested on their own. There would be corresponding downward and upward effects on the coefficient of value added should the simultaneity bias not be taken into account. (Manjón and Mañez 2016)

Olley and Pakes encountered these issues in their paper and introduced a model that mitigates this bias. The theoretical basis of their paper provided an estimation function by using a model which takes into consideration exit times and input decisions. Given that the econometric model of Ackerberg, Caves and Frazer builds upon the model, developed by Olley and Pakes, which built estimators to overcome the biases. (Olley and Pakes 1996) In STATA, this is sufficiently taken into account using the state variables, which works on the assumption that the conditional on other variables intangible assets are increasing in productivity.

Section 5.3 – Data in STATA

To analyse the hypothesis, the raw data was converted into panel data achieving a balanced panel of the observations over multiple time periods. The model was analysed through STATA using the *acfest* syntax as follows: number of employees as free variables, intangible assets and tangible assets as state variables, materials as proxy variables. The dependent variable reported is value added. Further information about the syntax in STATA can be found in the Appendix.

Some variables had a value of zero as their reported value for intangible assets, tangible assets and value added. This posed a problem as the model required using logarithmic inputs – taking the ln (0) would appear as a missing value in the data sample. To resolve this issue, the variables have to be transformed hyperbolically using ln (value + $(\text{value}^2 + 1)^{1/2}$). While the values for the number of employees are non-zero, all the variables were transformed using this hyperbolic function for simplicity.

Section 5.4 Data Selection for Robustness Check

In carrying out the robustness check, a different data sample was using by refining some of the parameters in the AMADEUS database. Using the same selection criteria with two differences: values for the variables needed not to be missing from 2015-2019 and extended to sample to include the entire European Union. Data was still taken for the entire investigated time frame 2011-2019. The countries were not selected individually but as a whole thus the database itself filtered out many of the countries. The sample does not include all 27 Member States + United Kingdom in the sample. The countries in the sample – Austria, Belgium, Czech Republic, Finland, Italy, Slovakia, Spain and Sweden yielding a sample of 9586. The same steps to transform the variables into hyperbolic data was used.

Section 6 - Results

This section consists of an analysis of results obtained using the economic model described above. The dataset consisted of all firms with available data across the 2011 – 2019 timeframe. I will first analyse this data sample looking a two time periods: 2011-2019 and 2015-2019. Two separate time periods are used as the data sample used for the robustness checks included complete data for all variables in 2015-2019 but has some missing data for variables in 2011-2014.

6.1 Effect of Intangible Assets on Value Added - Results

I ran an analysis on the different sized firms to understand the difference in impact of intangible assets on value added using data from the selected seven in the European Union (EU7). I also run the analysis on the two time periods 2011-2014 and 2015-2019.

6.1.1 Effect of Intangible Assets on all firms

The first set of results looks at all firms in the sample to set a baseline estimate against the results for the coefficient $ß_x$ for small and medium sized enterprises and large and very large enterprises.

2011-2019 VARIABLES	(1) Value Added
Intangible Assets	0.0511**
	(0.0243)
Tangible Assets	0.0964**
	(0.0425)
Number of Employees	0.448
	(0.279)
Observations	260,136

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for all the firms EU7 in 2011-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

If intangible assets increased by one percent, we expect value added to increase by 5.1% and is statistically significant. Thereby, implying that intangible assets do have an impact on a firm's value added. The literature on intangible assets also yields a positive impact of intangible assets on value added.

The next stage involved running the regression on all firms in the reduced timeframe 2015-2019. A shorter timeframe was used for two reasons – firstly, the database AMADEUS had the most complete data over this time period and secondly, because in 2017 the EU made announcements regarding changes in intellectual property law. ('Intellectual Property' 2016)

2015-2019	(1)
VARIABLES	Value Added
Intangible Assets	0.0802***
	(0.00442)
Tangible Assets	0.165***
	(0.00757)
Number of Employees	-0.163**
	(0.0669)
Observations	130,233
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

This figure shows the results obtained in the regression using acfest syntax on STATA for all the firms EU7 in 2015-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error

If intangible assets increased by one percent, then value added increases by 8.1%. and is statistically significant. There is an approximate 3% difference between the results, with a higher coefficient in the recent years. I can infer that the impact of value added on intangible assets in the last five years than it was in the first five years. The significant increased could imply that there has been an overall improvement in the allocation and investment of intangible assets. The baseline positive value for the coefficient, $ß_x$, shows accordance with the literature, but does not validate my hypothesis as it investigates the difference due to firm size.

The coefficient for number of employees ($ß_l$) is interesting as it is negative implying an increase in number of employees decreases the firm's value added from 2015-2019. This could be due to diminishing marginal returns of labour. While the coefficient for $ß_l$ in 2011-2019 is positive implying an increase in the number of employees would increase the firm's value added. The inconsistency between the different time frames is interesting but not relevant as the coefficient of interest is, $ß_x$. Further research should look into why this persists.

6.1.2 Effect of Intangible Assets on Small and Medium Sized Enterprises

In this stage, I ran the economic model using the same data sample but omitting firms with greater than or equal to 250 employees. I defined a firm as a small and medium sized enterprise using the European Union definition. ('What Is an SME?' 2016)

2011-2019	(1)
VARIABLES	Value Added
Intangible Assets	-0.0275***
	(0.00781)
Tangible Assets	-0.0199*
	(0.0103)
Number of Employees	2.215***
	(0.165)
Observations	215,930

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for small and medium sized enterprises in the EU7 from 2011-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The results for $ß_x$ is negative; therefore, if intangible assets increased by one percent, we expect value added to decrease by 2.8%. Furthermore, the p-value is statistically significant at all levels. According to the literature, intangible assets positively impact value added thus the regression should have yielded a positive coefficient. Yet, this negative coefficient does not disprove my hypothesis as it tests for a difference in impact not a positive or negative impact.

2015-2019	(1)
VARIABLES	Value Added
Intangible Assets	0.0893***
	(0.00652)
Tangible Assets	0.187***
	(0.0122)
Number of Employees	-1.005***
	(0.203)
Observations	107,456

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for small and medium sized enterprises in the EU7 in 2015-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

On the other hand, in the 2015-2019 timeframe, the coefficient for $ß_x$ becomes significantly positive with a statistically significant p-value. There has been a significant increase in the impact of intangible assets on value added. This could be due to greater understanding among small and medium sized enterprises of the advantages of intangible assets and an improvement in efficiency or allocation. (Andersson and Saiz 2018)It could also be because the European

Union has been introducing better reporting practices of intangible assets on firm's balance sheet. (Amico 2012)

6.1.3 Effect of Intangible Assets on Large and Very Large Enterprises

In this stage, I ran the economic model using the same data sample but omitting firms with less than 250 employees.

2011-2019 VARIABLES	(1) Value Added
Intangible Assets	0.0628***
	(0.00444)
Tangible Assets	0.161***
	(0.0168)
Number of Employees	-0.0566
	(0.107)
Observations	42,219

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for large and very large enterprises EU7 in 2011-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The results for the coefficient of interest, $ß_{x,}$ is positive and statistically significant. If intangible assets increased by one percent, then value added increases by approximately 6.3%. $ß_x$ for small and medium sized enterprises in the same time frame is significantly difference. These results validate my hypothesis that there is a difference in impact between intangible assets on value added depending on the size of the firm. Increases in intangible assets have a greater impact on value added on larger firms than smaller firms.

2015-2019 VARIABLES	(1) Value Added
Intangible Assets	0.0658***
	(0.0106)
Tangible Assets	0.207***
	(0.0250)
Number of Employees	-0.152
	(0.251)
Observations	21,842

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for large and very large enterprises in EU7 in 2015-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The coefficient, $ß_x$, for these results is similar to the one above. If intangible assets increase by one percent, then value added increases by approximately 6.6%. This implies that for large and very large enterprises in the European Union there has not be much change in the way intangible assets are invested or allocated. This coefficient is also less than the coefficient obtained for $ß_{x,SME}$ within the same time frame implying than intangible assets have a greater impact on smaller firms than larger firms.

The dataset only took into account 7 countries in the EU – Belgium, France, Germany, Italy, Portugal, Spain and Sweden. The major limitation with this dataset is that there is a significant amount of missing data. Thus, it is hard to accurately evaluate the impact of intangible assets on value added. The next part of this section considers several robustness checks using two data samples for the entire European Union.

6.2 Robustness Check – Small and Medium Sized Enterprises

As seen in the results, above, the coefficient for $ß_x$ is negative for small and medium sized enterprises. This result is contrary to the literature on intangible assets that shows intangible assets positively contributing to value added. Given this deviation, I ran the model for small and medium sized firms from 2011-2014.

2011-2014 VARIABLES	(1) Value Added
Intangible As	-0.0259***
	(0.00942)
Tangible Ass	-0.0121
	(0.0127)
Number of E	2.010***
	(0.159)
Observations	81,424

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for small and medium sized enterprises in EU7 in 2011-2014. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The coefficient, $ß_x$, is negative – if intangible assets increase by one percent, the value added decreased by 2.6%. This coefficient is similar to the coefficient in the larger timeframe 2011-2019 which was -2.8. While, this result helps us understand why the larger time frame has a negative coefficient, it does not entirely explain why the coefficient in 2015-2019 is significantly larger and positive. A possible explanation could lie on the macroeconomic level as Europe was still going through and experiencing the aftereffects of the Financial and Euro Crisis.

All the literature showcases a positive correlation between intangible assets and value added, therefore, negative coefficients for $ß_x$ are against the norm. One possible reason for the negative coefficient is many small and medium sized enterprises do not have intangible assets i.e. a value of zero. To test this, I ran the model omitting firms with intangible assets equal to zero. The results of this test can be seen below.

2011-2019 VARIABLES	(1) Value Added
Intangible Assets	0.0819***
	(0.00993)
Tangible Assets	0.137***
	(0.0179)
Number of Employees	-0.00677
	(0.177)
Observations	127,814

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for small and medium sized enterprises EU7 in 2011-2019 omitting firms with intangible assets equal to zero. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The coefficient for $ß_x$ obtained was similar to the one obtained in the 2015-2019 timeframe, as shown in Section 5.1. From this, I can infer that the majority of data for the small and medium sized enterprises in 2011-2014 for intangible assets was zero, thus suggesting a growing awareness of the benefits derived from intangible assets in the European Union.

These results indicate not only the difference in impact between different sized firms but also difference in impact intangible assets have within small and medium sized enterprises. A firm with positive investment in intangible assets has an increasing impact on value added.

According to the literature, this positive increase has implications to growth, productivity and efficiency. (Ark et al. 2009)

6.3 Robustness Check using a Smaller Data Sample

The data sample used was transformed from time series data into panel data with no gaps. The countries included in this sample: Austria, Belgium, Czech Republic, Finland, Italy, Slovakia, Spain and Sweden. This yields a sample of 9586 firms. I ran the same economic model as above to see how the coefficient, $ß_x$, is affected with a change in the model specification.

6.3.1 Effect of Intangible Assets on all Firms

In this stage, I ran the model looking at all the firms in the data sample in the two time periods: 2011-2019 and 2015-2019.

2011-2019 VARIABLES	(1) Value Added
Intangible Assets	-0.0314***
	(0.00260)
Tangible Assets	0.0567***
	(0.00326)
Number of Employees	1.085***
	(0.00940)
Observations	76,571

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2015-2019 VARIABLES	(1) Value Added
Intangible Assets	-0.0319***
	(0.00480)
Tangible Assets	0.0568***
	(0.00513)
Number of Employees	1.093***
	(0.0153)
Observations	38,312

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for all the firms in 2011-2019 on the left and on the right for all firms in 2015-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The coefficient, $ß_x$, is negative implying that as intangible asset increases by one percent, value added decreases by 3.1% which is statistically significant. This similar to the results obtained when the model was run using small and medium sized enterprises in section 5.1. However, it is contrary to the results obtained when investigating all firms in the initial model. I then ran the model for the smaller time frame, which yielded a similar coefficient, $ß_x$, approximately -3.2%. A possible explanation is the countries in the sample which were not part of the original sample played a significant effect on the impact of intangible assets on value added, as a whole. (National Research Council 2009)

6.3.2 Effect of Intangible Assets on all Firms on Small and Medium Sized Enterprises

In this stage, I tested the model for small and medium sized enterprises using the same definition that classifies a SME as a firm with less than 250 employees. The model was tested using both timeframes 2011-2019 and 2015-2019.

2011-2019 VARIABLES	(1) Value Added
Intangible Assets	-0.0334***
	(0.00260)
Tangible Assets	0.0535***
	(0.00306)
Number of Employees	1.150***
	(0.0109)
Observations	72,346

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2015-2019 VARIABLES	(1) Value Added
Intangible Assets	-0.0320***
	(0.00441)
Tangible Assets	0.0544***
	(0.00434)
Number of Employees	1.163***
	(0.0164)
Observations	36,115

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for small and medium sized enterprises in 2011-2019 on the left and on the right for small and medium sized enterprises in 2015-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

Looking at the impact of intangibles on value added for small and medium sized enterprises yielded a negative coefficient for $ß_x$ in both time frames. If intangible assets increase by one percent, then value added decreases by -3.3 and -3.2% respectively. These results while also contrary to the literature, show that the results of small and medium sized enterprises in the initial data sample were not an anomaly. Another explanation may be since smaller firms in the data sample had zero as their value for intangible assets. To test this, I ran the model omitting firms that had intangible assets equal to zero.

	2011-2019	2015-2019
	(1)	(2)
VARIABLES	Value Added	Value Added
Intangible Assets	0.0310***	0.0370***
	(0.00601)	(0.00948)
Tanglible Assets	0.0331***	0.0594***
	(0.00927)	(0.0149)
Number of Employees	1.209***	1.121***
	(0.0437)	(0.0554)
Observations	27,944	13,655

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for small and medium sized enterprises in 2011-2019 on the left and on the right for small and medium sized enterprises in 2015-2019 omitting firms with intangible assets equal to zero. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The results of this model yielded a positive coefficient for, $ß_x$, in both time frames with similar values, which unlike the negative coefficients, are in accordance with the literature. (Ark et al. 2009) These results showcase the impact of having no intangible assets have on value added. Firms with intangible assets have a positive increase in value added compared with firms who do not. Therefore, these results highlight the importance intangible assets have on firms and the potential benefits for firms who have yet to invest.

These values also help explain the negative coefficient obtained in section 6.3.1. The majority of firms in this same hold a value for intangible asset equal to zero as seen by the change in the number of observations. The results of the robustness test after dropping firms with intangible assets equal to zero imply that the values obtained can be extrapolated to other countries not in the sample, given the relative similarity between the coefficients.

6.3.3 Effect of Intangible Assets on all Firms on Large and Very Large Enterprises

In this stage, I tested the model for large and very large enterprises using the same definition that classifies a SME as a firm with greater than or equal to 250 employees. The model was tested using both timeframes 2011-2019 and 2015-2019.

2011-2019 VARIABLES	(1) Value Added
Intangible Assets	0.0343**
	(0.0153)
Tangible Assets	0.156***
	(0.0355)
Number of Employees	0.809***
	(0.0832)
Observations	3,969

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2015-2019 VARIABLES	(1) Value Added
Intangible Assets	-0.00251
	(0.0313)
Tangible Assets	0.203***
	(0.0783)
Number of Employees	0.884***
	(0.152)
Observations	2,054

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for large and very large enterprises in 2011-2019 on the left and on the right for large and very large enterprises in 2015-2019. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

I looked at the positive coefficient (3.4%), $ß_x$, in 2011-2019 in comparison to the negative and statistically insignificant coefficient (-0.2%), $ß_x$, in 2015-2019 with the difference between the coefficient approximating 3.6%. In comparison to the results for large and very large enterprises in the initial data sample, the coefficients are contrary to the literature. However, the results for the initial time frame 2011-2019 yield similar coefficient – around 3% - for both small and medium sized enterprises as well as large and very large enterprises. This is contrary to my hypothesis that there will be a difference in impact of intangible assets depending on size of the firm.

From Section 6.2, we can see that the results of the regression are significantly impacted when firms hold intangible assets equal to zero. Therefore, I then ran the model looking omitting large and very large firms in the second time period which had a value of zero.

2015-2019 VARIABLES	(1) Value Added
Intangible Assets	0.0660**
	(0.0328)
Tangible Assets	0.249***
	(0.0728)
Number of Employees	0.685***
	(0.155)
Observations	1,963

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This figure shows the results obtained in the regression using acfest syntax on STATA for large and very large enterprises in 2015-2019 omitting firms with intangible assets equal to zero. The number of stars represent the degree of statistical significance and the number in brackets is the standard error.

The coefficient for $ß_x$, is now positive thereby implying an increase in intangible assets by one percent increases the value added by 6.6%. The value obtained is almost exactly the same as the value obtained for large and very large enterprises in Section 5.1.

The results for this robustness test evaluated the impact of intangibles assets on value added using a data sample with a number of different countries. This data sample also had a more complete set of data for 2015-2019. The results of this regression show that in the more representative time frame intangible assets have a greater impact on larger firms than they do smaller firms. While these results are contrary to the ones obtained in Section 5, they also prove my hypothesis that intangible assets have a different impact on value added depending on the size of the firm.

Section 7 – Conclusion

The results prove the hypothesis that there is a difference in the impact of intangible assets on value added depending on the size of the firm. The coefficient for large and very large enterprises is less than that of small and medium sized enterprises, which means that intangibles assets have a greater impact on the value added of small and medium sized enterprises than large and very large enterprises. This coefficient for $ß_x$ are similar in both time frames for small and medium sized enterprises and large and very large enterprises. Even though there are the number of observations is greater for small and medium sized enterprises that is to be expected given the breakdown of European economies that consist primarily of smaller and medium sized enterprises. The results also showed the positive impact intangible assets have on small and medium sized enterprises through the exclusion of firms with zero intangible assets. This could have further implications on increasing access and investment for small and medium sized firms.

Intangible assets are divided into different categories such as economic competencies, innovative property. (Corrado, Haskel, and Jona-Lasinio 2017) The level of investment in each category would differ depending on a firm's objectives. For example, firm A would invest more heavily in innovative property whereas firm B would invest more in economic competencies. While still categorised as intangible assets, the impact on value added would depend on in where the firm invested the most. This could have potential implications for efficiency, productivity and value added. However, the data sample do not have information about the breakdown of intangible assets by firm thus this is hard to test. This could help explain why the impact on value added on small and medium sized enterprises and large and very large enterprises is different.

The EU has directives which are applied to all the member states, but the way in which those directives are transcribed into law is the onus of the Member States. The framework for each member state remains the same. While country fixed effects are important due to changes in national policy, the results of the paper would more so be a test of the European Union's cross-border legislation. This study only looks at a handful of European Union Member states due to data specification but, given that different economies were represented the results can be extrapolated to the entirety of the EU. Further research should look at a country by country analysis at a firm level evaluating the impact of different sized firms.

Overall, the paper reached its objective ascertaining that firm size is an important factor in determining the difference in impact of intangible assets on value added. There is an approximate 8% increase to value added for small and medium sized enterprises compared with a 6% increase to value added for large and very large enterprises.

Appendix

The Model in STATA

The acfest command in STATA has the following syntax:

acfest *depvar* [if] [in], free(*varlist)* state(*varlist)* proxy(*varname)* [i(*varname)* t(*varname)* nbs(#) robust nodum second va overid

Depvar is the dependent variable, which represents the value added. Free() contains labour inputs, which is number of employees. State() consists the variables for intangible assets and tangible assets. Proxy() contains the variable for materials (sales – value added). All the data as seen by the Cobb-Douglas production function needs to be panel data in logs thus the panel variable i(company*)* and time variable t(*year)* needs to be identified. Robust obtains the standard errors robust to heteroskedasticity. Nodum measures the time dummies. Overid is the lag for intangible and tangible assets and the second lag for number of employees. (Manjón and Mañez 2016)

To obtain the proxy variable which is captured by ω_{it} (estimated productivity) a new term is generated by STATA using the syntax predict omega_hat [if] [in], omega. (Manjón and Mañez 2016)

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