1. FIRM-LEVEL PRODUCTIVITY AND EXPORTING: DIAGNOSING THE ROLE OF FINANCIAL CONSTRAINTS

1.1. INTRODUCTION

In this chapter, we explore how and why financial indicators affect firm-level total factor productivity and the exporting status of a firm. We address three relevant policy questions: 1) Do financial indicators affect firms' productivity levels?; 2) Do financial indicators affect firms' ability to enter international markets and export?; 3) Have financial supply conditions and domestic aggregate demand during the crisis affected firms' ability to become exporters?

One transmission channel from financing to trade is that in order to export and/or produce abroad, firms often have to incur fixed and sunk costs (distribution networks, information costs, products customization, overseas production facilities etc.). This fixed cost investment accompanying internationalization has to occur even before export revenues can be reaped. But the financing of these costs may exceed a firm's internal financing ability and require external financing.

Academic research has shown that only the most productive firms with a low marginal cost of production can afford to invest in fixed costs of internationalization and become exporters (Melitz, 2003). Internationalization therefore requires high productivity levels at firm-level. This requires an increase in technical efficiency which will spur firm growth and result in larger firm size (Mayer and Ottaviano, 2007).

Firm growth typically requires financial means that exceed the firm's internal ability to generate funds. The literature has typically pointed out that only high productivity ensures the ability of a firm to recoup the fixed cost associated with exporting and to repay the loans undertaken to finance them. Conditioning on productivity levels, firm size may have an additional role to play since a larger firm may have more collateral which ultimately may affect its chances to obtain a loan and may facilitate a firm's access to finance.

However, the need for financing in trade is not just needed to cover fixed costs, but also to finance the ordinary trade transactions. As shown by Antras and Foley (2011), the most commonly used financing for ordinary trade operations do not involve direct financial intermediation by banks but involve cash in advance. As such we would also expect the financial health of a firm and its cash position to be an important determinant of exporting.

More productive firms seem to rely less on outside bank financing. Earlier literature has shown that more productive firms appear to be in a better financial health and rely less on outside financing (Altomonte et al., 2012). The Altomonte et al. (2012) study also shows that when more productive firms apply for bank financing they are more likely to get it. As such we would expect more productive firms to be less financially constraint. This can be understood as follows. First, a highly productive firm is likely to have better investment projects that yield higher returns than the market interest rate, which is likely to make banks more interested. Second, banks may perceive highly productive firms as lower-risk investments since high productivity signals their past success. As such we expect more productive firms to be in a better position to obtain financing and to engage in exporting. The relationship between financing and productivity may thus run in two ways i.e. from finance conditions to productivity and from productivity to better financing conditions. This is likely to generate some endogeneity issues in the regression analysis which we need to address.

While financial indicators may have a role to play in allowing firms to reach higher productivity levels and to engage in exporting, they are unlikely to be the only factors that matter. In addition to financial conditions, the evolution of domestic aggregate demand is also likely to matter. Both domestic demand as well as shifts in demand in abroad will be controlled for.

To study firm-level productivity and exporting decisions by firms, we use the EFIGE firm-level dataset with survey questions on firms' internationalization activities that was collected by Bruegel and which we have merged with Amadeus balance sheet data, containing all the publicly available firm characteristics over time (2001-

2011). The seven countries included in the EFIGE survey are: Spain, Italy, France, Germany, UK, Austria and Hungary, with around 15,000 firms covered by the survey.

Our methodology consists of a three step approach.

First, we determine the role that financial indicators play in explaining total factor productivity differences of firms across countries.

Second we analyse the role that financial indicators and domestic demand evolutions play as a determinant in firm internationalization (exporting status) whilst controlling for firm productivity. Financial indicators may affect exporting directly, through their effect on firm productivity, or may have additional effects that go beyond their effect on exporting.

And **finally**, we investigate whether the financing conditions during the crisis had a dampening effect on firms' exports or whether domestic demand evolutions played a bigger role.

Our findings can be summarized as follows. Favourable aggregate demand conditions at home positively affect firms' productivity levels.([26]) Controlling for domestic demand and consumer confidence, firms in our sample have higher productivity levels in countries with higher financial development. Thus, the total factor productivity of firms is positively correlated with credit supply conditions in the home country. Put differently, when a firm operates in a country that has more favourable bank loan supply conditions, the productivity level it can achieve is higher.

In terms of firm-heterogeneity within a country, we find that financial health of a firm is a determinant of high productivity. In other words, under equal macro-conditions of credit supply and demand, financially healthier firms, in terms of lower indebtedness and higher ability to repay interests on loans, have a higher level of productivity. The financial crisis since 2008 has however negatively impacted the within-firm productivity levels of incumbent firms in all countries in our data. In line with earlier literature, we also find that size is a determinant of high productivity. Thus, larger firms are more productive where we measure size in terms of "number of employees".

In line with Manova (2012) our results show that productivity levels are lower in sectors that operate with a lot of fixed assets, but higher in sectors that rely more on external financing. However, during the crisis, fixed assets (collateral) appear to have been an advantage, since productivity levels of firms with fixed costs experienced a lower downturn than in other sectors. We find no evidence that firms in financially vulnerable sectors, i.e. those that rely more on external financing than other sectors, were particularly hit during the crisis.([27])

In terms of exporting we base our analysis on a cross-section of firms for which we have information on export market participation. Our results confirm that firm-level productivity is an important direct determinant in explaining participation in export markets, which is in line with the heterogeneous firm literature. But the institutional environment in terms of a country's financial development and the credit supply, only indirectly affect firm-level exporting through the productivity channel. Bank credit supply conditions as a determinant of the export participation of firms, over and above their role through firm productivity, appears to matter little. In addition to firm productivity, we find that firm size is an important direct determinant of exporting. Controlling for firm-productivity, larger firms have a higher probability of exporting.([28]) We also find that financially healthier firms are more likely to participate in export markets.([29])

([26]) We are aware of potential reverse causality issues between productivity and domestic demand, this is why we regress firm-level productivity on an aggregate country-level measure of domestic demand to avoid endogeneity.

([27]) These results hold both under ordinary least squares (OLS) and instrumental variable regressions, while controlling for country and two-digit sector fixed effects. Inclusion of firm fixed effects and four-digit level sector fixed effects yields the same results but raises the explanatory power of the model.

([28]) Potential endogeneity between the firm-level variables in the regressions is addressed by including productivity and size from a period prior to the cross-sectional data as well as with two-stage least squares instrumental variable regressions.

([29]) The results on the firm-level exports equation that we report here are robust to quite a few estimation methods. Results are qualitatively the same when using a probit model (with marginal effects), a linear probability model or

More important to understand the different exporting patterns across countries are demand conditions. Aggregate domestic demand negatively correlates with the probability of firms exporting. Thus, in a country with favourable aggregate domestic demand conditions, firms of similar size and productivity tend to have a lower probability of export market participation than in a country where domestic demand turns weak or is shrinking.

Based on our exporters' analysis, we can obtain "out-of-sample" predictions for the years during the crisis. This allows us to make some tentative inferences about what happened to exporter status after the crisis, even though we do not actually observe it. The fall in firm-level productivity levels observed in all countries during the crisis, negatively impacts the probability of firms to become exporters. However, the probability of exporting appears to be heavily affected by aggregate domestic demand conditions in the country where firms are located. Since domestic demand turned sour after the crisis in most EU countries, the lower domestic demand at home appears to have led to an increase in the probability of exporting for EU firms in the post-crisis years despite their lower productivity levels.

Spain is probably a good example of this phenomenon. By now it is well-known that Spanish export market performance during the crisis went up. In the light of the micro-economic results on firms obtained here, at least a partial explanation can be provided: despite the less favourable credit conditions that applied in Spain after the crisis, the incentive of firms to start exporting more, may well be driven by the collapse of domestic demand in Spain.

While the inverse relationship between aggregate exports of a country and domestic consumption is well-understood in macro-economic terms, to our knowledge this relationship has never been documented with micro-level data. The advantage of firm-level data is the distinction between *how much* is exported at firm-level (the intensive margin) and *how many* firms are engaging in exporting (the extensive margin). What this study shows is that domestic demand evolutions at country-level significantly affect *how many* firms are exporting. Data limitations prevent us to also study the intensive margin of exporting and will be left for future research.

an instrumental variables regression using a two-stage least square estimation. The latter method better accounts for the potential endogeneity in the firm-level right-hand side variables such as firm-level productivity, size and financial health, all impacting the exporting decision. The endogeneity of the firm-level regressors is confirmed by a Hausman-test and the relevance of the instruments is confirmed by the F-tests.

1.2. DESIGN AND METHODOLOGY

In this section we better explain the design and methodology used in this chapter. Our contribution will not lie in the novelty of the financial indicators that will be used, but instead we will turn to existing studies to guide us in our choice of financial indicators at country and sector-level (Cuerpo, Drumond, Lendvai, Pontuch, Raciborski, 2013). Additionally, due to the highly disaggregate nature of our data, we can also control for firm-level financial indicators, which has not been done before.([30])

The main purpose of this paper is to see how financing conditions (country-, sector-, firm-level) affect firms' exporting status. Ideally, we would like to go beyond the extensive margin and analyse the effects of credit constraints on the intensive margin of exports i.e. the value of exports, but data limitations at this point do not permit us to do so since at present no EU-wide datasets are available that include firm-level *values* of exports.

In this section we will describe in detail the analysis that we aim to pursue which consists of three steps.

We first study the determinants of firm-level productivity based on time-varying data from 2001 to 2011 and to what extent productivity levels and growth correlate with financial indicators at country-, sector- and firm-level as well as other controls. In view of the large number of macro-indicators that we consider and their potentially overlapping information content, we apply a

([30]) Our purpose is not to disentangle credit supply from credit demand conditions. Our purpose is to study how macro-economic credit conditions (see appendix for data) affect firm-productivity and firm-level exporting status.

"principal-component" analysis which allows us to substantially reduce the number of explanatory variables to include in the subsequent firm-level productivity and export regressions. Moreover, a principal components approach ensures orthogonality of the main factors when used as regressors.

Next, for a subsample of EU firms with information on their exporting status in a particular year, we study the direct role of financial indicators as a determinant of exporting, whilst controlling for firm-productivity, which in turn may be affected by financial indicators. As such we study the direct and indirect (through productivity) role that credit supply conditions and demand evolutions play in explaining exporting status.

Finally, we use the estimated coefficients arising from our cross-sectional subsample of firms to get "out-of-sample" predictions for the exporting status of firms during the crisis years as a function of the change in financial indicators and domestic demand evolutions in the country where the firm is located during these years. These predictions will allow us to give an indication of how the average "probability to export" at firm-level changed over time.([31])

The different analytics involved in this study are:

- Estimate productivity distributions of firms in different Member States
- Compare productivity distributions before and after the crisis
- Regress total factor productivity on financial indicators of credit supply (see below for a description) and other control variables such as domestic demand
- Estimate an empirical exporters model as a function of productivity, size, financial indicators and other controls
- Make inferences about the propensity to export of firms in the years after the start of the crisis

([31]) The probability of exporting is what the literature refers to as the extensive margin of exporting, since it tells us how many firms are likely to engage in exporting.

1.3. DATA

For this purpose we will use the EFIGE firm-level dataset with survey questions on firms' internationalization activities that was collected by Bruegel, merged with Amadeus data which has all the publicly available firm characteristics over time (2001-2011).

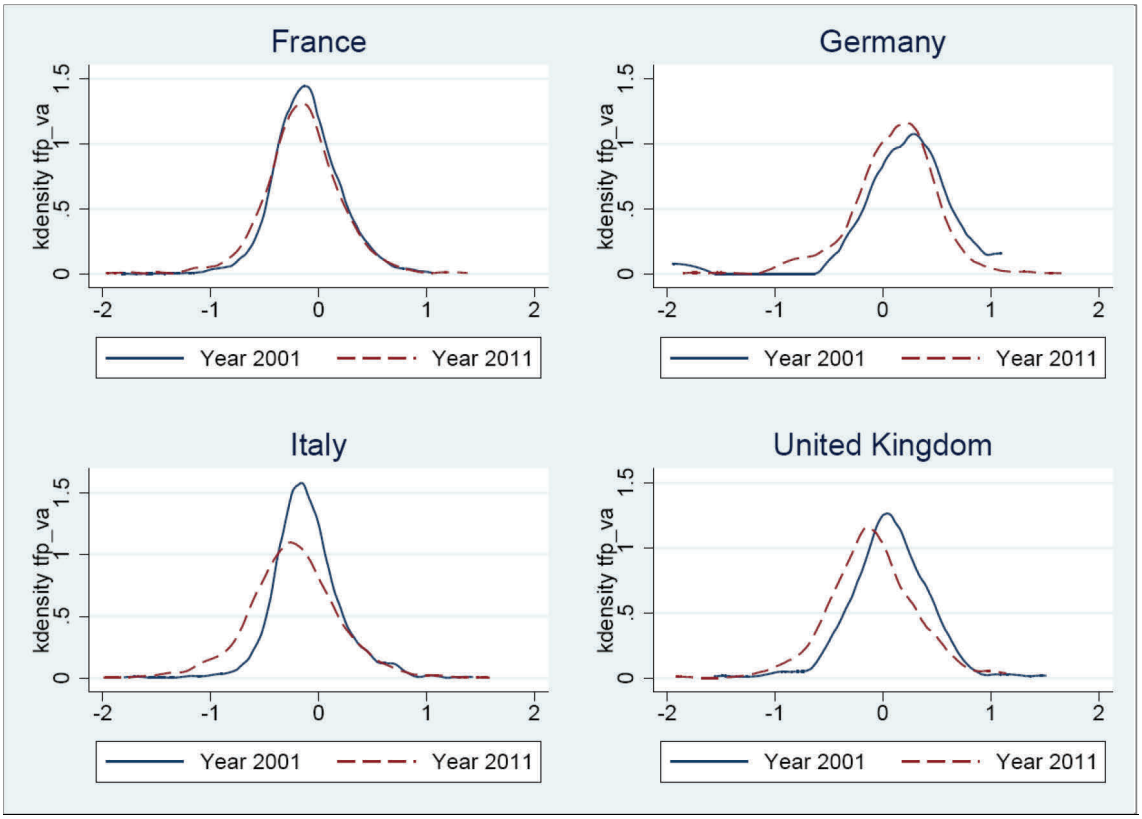
In addition we will use data on financial indicators. Our approach is a combination of the indicators used in earlier studies and additional ones at firm-level. As in previous studies, the challenge is to disentangle credit supply conditions from demand aspects. For this reason we will consider indicators from various sources and at various levels of aggregation.

In view of the large number of financial indicators that exist and the high level of correlation amongst several of them, we apply principal-component analysis. This amounts to generating a single scalar that contains the orthogonal and uncorrelated parts of the various indicators that we want to control for in the regression. This factoring of variables preserves degrees of freedom since it allows for a reduction of the number of independent variables. This will be explained more in detail in the regression section.

Unfortunately we do not have information on the firm-bank relationship as in Amiti and Weinstein (2012) on Japanese firms, nor do we have information on actual export values shipped by firms. Therefore we cannot comment or investigate the intensive margin of firm-level exports, since our data only bear on the export market status of a firm. Also, we do not know whether the firm is a new exporter or a long existing exporter. The cross-sectional information on exporting only gives us an indication of exporting status at a given moment in time, which is clearly a limitation of the analysis.

It is also important to point out that our data cannot account for new entrants in the market. Instead, our data consists of a "balanced" panel of incumbent firms that we follow over time from before the crisis (2001) till after the outbreak of the crisis (2011).

Graph II.1.1: **Kernel density distributions of firm-level productivity (in logs)**



Source: EFIGE data, BRUEGEL

1.4. DESCRIPTION OF RESULTS

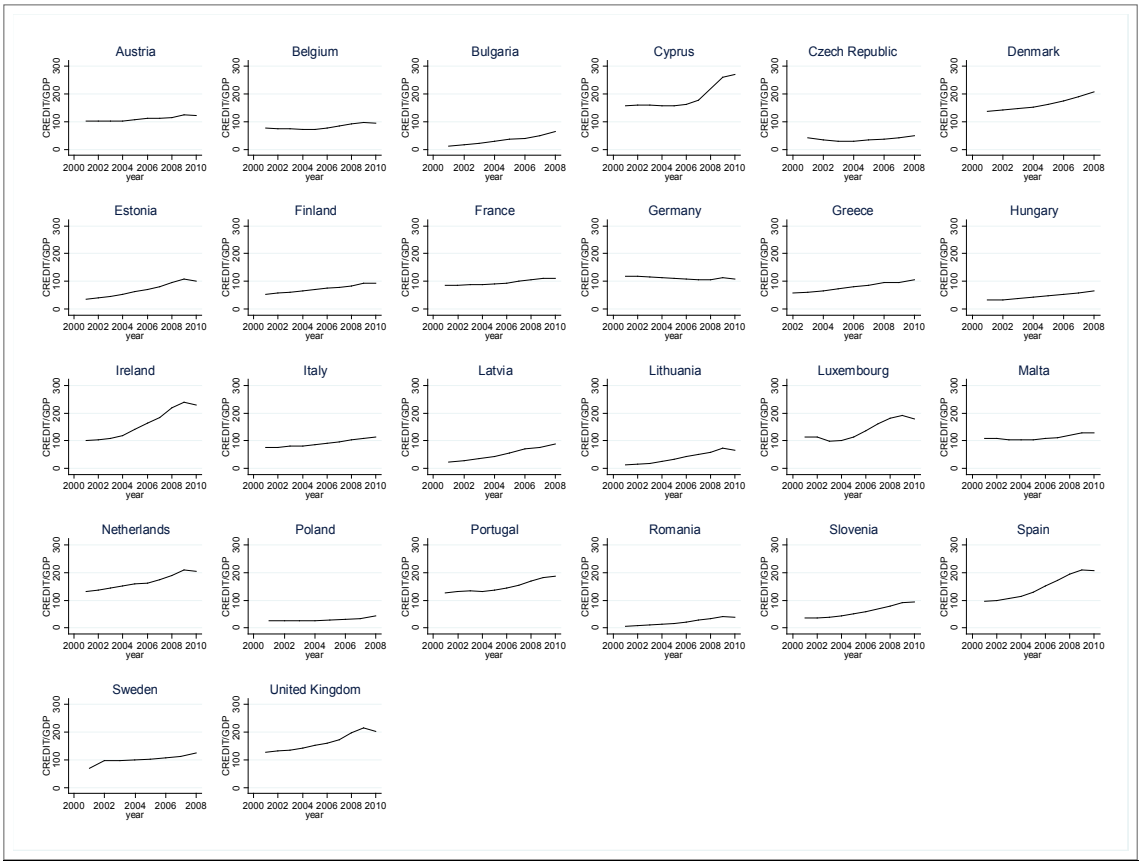
1.4.1. Productivity distributions of firms in different Member States over time

Before we engage in regression analysis, we study the evolution of both the dependent and independent variables that will be used in this process. Thus before we analyse the role of financial indicators on firm-level productivity levels and growth over time, we first document how our dependent variable of interest, i.e. firm productivity, has evolved over time. While there are many different methods around to estimate firm-level productivity, in this study we will be using the method proposed by Levinsohn and Petrin, which was also used in other studies using the EFIGE data (see Appendix B for more on this method).

Graph II.1.1 above shows productivity distributions for the four countries in our data for which we had sufficient information to compute firm-level total factor productivity (TFP) distributions([32]). For all countries we find that after the crisis, the productivity distributions shifted to the left and there are more firms in 2011 with lower levels of productivity than before the crisis in 2001. Also, there appear to be fewer firms with high productivity levels as shown by the shorter right-hand side tail of the dashed lines for most countries. The exception is Germany where the past decade seems to have generated some "winners" i.e. generating a few firms with very high productivity despite the crisis outbreak in 2008. But for the other three EU economies shown here (France, Italy, UK), there are fewer highly productive firms in 2011 than there were in 2001. Our data consists of a "balanced" panel of incumbent firms that we follow over time from before the crisis (2001) till after the outbreak of the crisis (2011). What our data show is that for

([32]) Graph II.1.1 shows Kernel density functions of firm-level total factor productivity (in logs).

Graph II.1.2: **The ratio of private credit as a share of GDP**



Source: WORLD BANK, Beck (2012) data

incumbent firms, the "within"-firm productivity has decreased over time. Put differently, firms that were in the market in 2001 and were still there in 2011, lost productivity.

A simple test on the differences in means of the distributions indeed confirms that for France, Italy and UK, the mean level of productivity in 2011 was significantly lower than in 2001. For Germany we do not find a significant difference in the means of the distribution even though from Graph II.1.1 we can clearly see that even in Germany the distribution is more skewed to the left. The mean for Germany seems not affected because the larger number of low productivity firms in 2011 are offset by a small number of highly productive firms that pull up the mean value, leaving it largely unchanged. But the equal average hides the fact that many firms' productivity dropped, also in Germany.

The negative impact of the crisis on total factor productivity (TFP) levels is confirmed when regressing firm-level TFP on a crisis-dummy and country dummies, as we do in Table II.1.1 below. Results for the effect of the crisis on average productivity of incumbent firms are shown in the first column of Table II.1.1.

The negative and significant sign confirms the reduction in productivity. This is a remarkable fact, since typically the productivity of firms should be going up over time and its distribution if anything would be expected to shift to the right. The remainder of this paper will next ask itself, whether this reduction in productivity levels is the result of the financial crisis and of a change in the financial indicators that go along with it, or whether other evolutions coinciding with the financial crisis were more important.

1.4.2. Country-level financial indicators

In line with the study by Cuerpo et al. (2013), we consider the evolution of fifteen different country-level macro financial indicators (listed in Appendix A) before and after the crisis consisting of series from the European Commission, the Bank Lending Survey, the SAFE dataset and the INDICSER data. The country-level variables we consider as potential controls for our regressions later on are the following:

Financial indicators of domestic credit supply conditions:

1) Ratio of private bank credit over GDP (World Bank data, Beck (2012) from 2001-2010)([33])

2) Return on equity of banks (INDICSER, 2001-2011)

3) Non-performing loans of banks (INDICSER, 2001-2011)

4) Exposure of banks to foreign high risk claims notably to Greece, Portugal and Ireland as a percentage of total bank assets (INDICSER 2001-2011)

5) Banking concentration defined as the assets of the three largest banks of a country as a share of the assets of all the commercial banks (World Bank, Beck (2012) from 2001-2010)

6) Banks tightening of standards for obtaining credit by firms (Bank Lending Survey, 2003-2013)([34])

Financial indicators of domestic demand conditions:([35])

7) Consumer sentiment indicator by country and year (European Commission)

8) Economic sentiment indicator by country and year (European Commission)

9) Unemployment rate by country by country and year (European Commission)

10) Demand for loans by Entreprises (Bank Lending Survey, 2003-2013)([36])

The first variable (credit/GDP) is what Manova (2012) interprets as the "level of financial development" of a country, i.e. whether a country has a developed financial system, measured by the extent to which credit flows to the private sector. A look at Graph II.1.2 suggests that the evolution of this ratio is quite heterogeneous across EU countries. Although it seems to suggest that ever since the crisis, in most countries, this ratio has not gone down. This is already an important observation to note, i.e. that during the crisis years, especially the later ones, the stock of available credit continued to grow. However, the rate at which the credit stock increased was decreasing over time during the crisis.([37])

1.4.2.1. Regressing financial indicators on crisis dummy

When regressing credit over GDP (credit/gdp) on a crisis dummy taking a value of "1" in post-crisis years and a value "0" in pre-crisis years and including country-dummies indeed suggests that the ratio of credit over GDP is significantly higher in post-crisis years. This can be seen from the sign and significance of the coefficient on the crisis dummy reported in column 2 of Table II.1.1. The same positive trend arises when we clean the ratio

([33]) This ratio is defined as (credit given to the private sector deflated by the CPI / GDP deflated by CPI). In our analysis we do not want this number to be affected by the movement in the underlying GDP series of the denominator. For this reason, we multiply this ratio by the "GDP deflated by CPI", to just get the private credit evolution over time. In order to make this number comparable across countries we then consider the percentage variation in the private credit variable over time.

([34]) The BLS survey is incomplete since responses to questions are available only for some countries and for some years and the coverage for EFIGE countries is not good which is why we had to drop this variable from the analysis later on.

([35]) The inclusion of domestic GDP as an additional control for aggregate country-level demand evolutions does not affect our results.

([36]) Again the coverage of this question for EFIGE countries is not good which is why we had to drop this variable from the analysis later on.

([37]) We have no information on other sources of financing via the capital markets that may be available for some firms such as the issuing of shares or bonds, so our credit supply only captures bank financing. However, evidence in EFIGE shows that, with the exception of UK firms, a very small minority of firms in Europe uses capital market instruments, with the prevailing (>80%, and >90% in some countries) of firms turning to banks for financing.

Table II.1.1: **Regressing financial indicators on crisis dummy**

Dependent variable	Crisis-dummy is "1" after 2008 and "0" before	Country-dummies	Observations	R- squared
	(1)	(2)	(3)	(4)
1) Credit/gdp	36.677***	YES	242	0.91
Credit (in logs)	0.536***	YES	242	0.817
Δ ln Credit	-0.006***	YES	213	0.582
2) Exposure to Foreign risk (in logs)	0.393**	YES	54	0.868
3) Bank concentration	-2.354*	YES	257	0.881
4) Return on Equity for banks	-10.471***	YES	323	0.301
5) Banks Tightened (%) (standards for obtaining credit)	7.039	YES	24	0.322
6) Non-performing Loans of banks	1.916***	YES	72	0.565
7) Consumer sentiment	-10.579***	YES	88	0.709
8) Economic sentiment	-10.190***	YES	88	0.365
9) Unemployment rate	2.170***	YES	88	0.617

Source: See Appendix A for data sources

from the movement in GDP (as explained in footnote 33), which is reported in the second row of Table II.1.1 (ln Credit). As such we conclude that the average "stock" of credit in Europe has not gone down after the crisis, although country heterogeneity is substantial as shown in Graph II.1.2.

Next, in Table II.1.1 we also consider the "change in credit" (Δ ln Credit). A regression on a crisis dummy with value 1 for post-crisis years now shows that this has gone down. As such we can conclude that the average "flow" of credit in Europe has decreased during the crisis. However, from the observed reduction in loans, we cannot conclude whether this is a demand- or a supply-driven phenomenon. Whether this is a reflection of banks reducing the credit they allow to flow to firms, or whether it reflects the fact that firms apply less for credit due to weak demand and lower investment opportunities is not so clear. A recent study for Belgium (Van Hulle et al., 2012) has shown that banks' ratio of loans to total assets remains very stable over time even during the crisis, suggesting that banks did not reduce their credit supply. About 75% of credit demand is from SME firms and another 25% from large firms. Especially SME firms seem to have reduced their demand for credit from banks during the crisis. This suggests that lower credit to firms was a demand side phenomenon. A recent study by the ECB however showed that for the Eurozone area as a whole, revealed a difference between the "north" and the "south" of Europe. While credit during the crisis continued to grow in the northern countries, it turned negative in the southern ones. The ECB singles out the "lack of demand" of SMEs as the main reason for lower credit to firms. But at the same time there seems to be stricter banking scrutiny of loan demands from SMEs.([38]) Our findings reported in Table II.1.1 involve averages across EU countries and seem to confirm the ECB's findings.

Table II.1.1 summarizes the results of similar regressions for the macro-series above where we regress the relevant series both on a crisis-dummy and country-dummies. In these regressions we include all EU countries. A first and tentative conclusion can be drawn. According to Table

([38]) This study was discussed in the financial press (De Tijd, 27/09/2013).

II.1.1, the crisis seems to have negatively affected banks' profitability in terms of their return-on-equity. This resulted in breakups of banks in the banking sector which decreased market concentration. The amount of credit that flowed to the private sector has remained on a growing path as a share of GDP. This is already a first indication that the reduction in average productivity levels of incumbent firms that we find is unlikely to be solely caused by a reduction in the supply conditions of credit. The average stock of credit available economy-wide seems to have gone up rather than down in crisis years. We assess more correctly the importance of financial indicators in explaining productivity levels of firms in subsequent sections.

The results for the other macro-indicators and their evolution during the crisis are also listed in Table II.1.1. It can be noted that non-performing loans in banks have gone up, as well as banks' exposure to foreign high risk claims in vulnerable EU countries. The survey results also indicate that banks have tightened their credit standards during the crisis years and that the demand for loans by firms has gone down.

Furthermore, we can see that consumer sentiment and economic sentiment in general have decreased significantly after 2008 and that the average unemployment rate has gone up.

There are however a number of important limitations to this data. First, the Bank Lending Survey (BLS) covers only four countries present in the EFIGE survey (Germany, Italy, Spain and Austria). The questions from the survey that we are interested in such as the "number of loans to enterprises" are only covered for the period 2007-2011. The SAFE data covers even a more limited number of years. The incorporation of these short time series from BLS and SAFE in our regressions reduces the number of observations substantially and renders the estimations unstable. Therefore we decided to reduce the number of country-level variables to the remaining eight series for which we have a longer time-span and a wider country-coverage available.

1.4.2.2. Principal component analysis on the macro-economic indicators

Instead of including all the macro-economic indicators as explanatory variables into our empirical regression model on productivity and exporting status, we prefer to first apply the technique of factoring, synonym for a principal component analysis. Factoring aims to reduce the number of variables in a regression analysis whenever these variables are highly correlated and involve overlapping information content. With factoring, we reduce the number of relevant variables to include in the regression while still keeping the non-overlapping content (the principal components) of the underlying variables. When we apply factoring on our macro-economic data series of indicators, two principal components emerge: one "supply" group of financial indicators and another consisting of a "demand" group of indicators.

These two principal components can then be used as explanatory variables in our regression framework to see to what extent financial indicators contribute to the explanation in the change of firm-level total factor productivity.

The first principal component captures the information content in the first six macro series listed above starting with the *credit/GDP ratio* and involving variables related to the *banking sector*. These variables all clearly belong more to the supply-side aspects of credit allocation. The interpretation of this composite variable is thus that the higher it is, the more favourable credit conditions are (credit-**supply** variable).

The second principal component points at overlapping information content in the consumer and economic sentiment as well as unemployment conditions at country-level. The first two variables (consumer and economic sentiment) vary positively with the principal component, while unemployment varies negatively with this composite variable. This second principal component can be thought of as capturing domestic demand-side aspects. In other words, the stronger the consumer confidence and the lower the unemployment rate, the stronger the domestic demand in a country (**demand).** In subsequent sections we additionally consider the firm-level financial indicators such as collateral, indebtedness and interest repayability indicators. Again we will factor these variables in order to obtain one principal component to insert as an additional

independent variable in the regression, to which we refer as financial health at firm-level (**financial health** variable).

1.4.3. Sector-level indicators

A recent paper by Manova (2012) has pointed out the importance of additional variables that may impact firms' access to finance. A first one is the "asset tangability" and a second one is the "financial vulnerability". The first variable captures the extent to which a firm operates with fixed tangible assets and the second one captures the extent to which a firm relies on outside capital for its investment. Both variables are defined at sector-level and averaged over time to avoid endogeneity issues in our firm-level regressions. We obtain the first variable from Amadeus and the second one from Manova (2012).

1.4.4. Firm-level financial indicators

Firm-level financial variables are likely to be correlated with a firm's productivity level and as such affect its exporting status. For this reason we consider firm-level indebtedness and interest repayability conditions as well as an often used index of financial health i.e. the Whited-Wu index (2006). The definitions of the variables can be found in Appendix A.

When factoring the firm-level financial variables we obtain one principal component to insert as an independent variable in the regression, which we refer to as **financial health**. To reduce the endogeneity, in the OLS regressions we lag the financial health factor by two years. For robustness we also engage in an instrumental variable, two stage least squares regression where we instrument all firm-level variables with lagged values.

1.4.5. Regressing financial indicators on firm-level productivity

In this section we describe the regression results of a panel regression where the dependent variable is the log of firm-level total factor productivity (obtained by using the methodology of Levinsohn and Petrin) between 2001-2011. We will also point out some limitations in the research design and data that should be taken into account when interpreting the results.

The results are reported in Table II.1.2. In that table we build the model step by step. The first column shows the sign and significance of a crisis dummy on TFP levels whilst at the same time controlling for country- and sector-level dummies in the regression. The crisis dummy confirms the results of Graph II.1.1, i.e. average productivity levels of firms dropped during the crisis. This is a robust result which is independent of the specification.

A first set of independent variables are credit supply conditions which vary across countries and over time (as illustrated by Graph II.1.2). They appear to be an important determinant to explain varying productivity levels per country. The results in Table II.1.2 suggest that when financial development of a country is stronger and credit supply conditions in an economy are more favourable, this results in higher average productivity levels of firms.

A second set of independent variables consist of aggregate domestic demand conditions which also vary by country and by year in our data. The stronger the domestic demand in a country, the higher the average productivity of firms in that country.

Both the credit supply variable and the domestic demand variable are aggregate variables defined at country-level, thus there is little potential for endogeneity to plague the results. Still, changes in the aggregate environment may affect firm productivity only with a lag. To allow for this delayed effect, in the regressions we include the demand and supply variables with a time lag, but even in the absence of such a lag, results are quite similar.

In order to verify whether demand abroad has an effect on domestic firm productivity we also include a time varying measure of EU GDP. This variable appears to have a positive and significant (or marginally significant effect) on firm-level productivity.

As third set of independent variables consist of firm-level controls such as firms' financial health. This time-varying variable appears to be positively correlated with firm productivity, i.e. financially healthier firms (lower indebtedness and higher cash flow) also appear to be more productive. An

additional firm-level control variable in the regression is the level of employment in the firm. This variable controls for firm size and is arguably a better one than sales, since sales may not just be driven by size but higher sales may stem from higher prices instead of larger volume. With the firm-level regressors we face a potentially serious endogeneity problem since financial health and employment are just like productivity observed at firm-level. We address this in several ways. In the OLS regressions, we start by lagging the two firm-level variables in order to avoid spurious correlation with productivity. But this may arguably not be sufficient to fully address the endogeneity issue since firm-level variables can be persistent over time. As a further test of our results, we run instrumental variable regressions where we instrument the endogenous firm-level variables with one and two period lags and the values in 2001 which is a year prior to the data analysis used in the regressions. The results of the IV-regression two-stage least squares are reported in column (7) of Table II.1.2. What is re-assuring is that the coefficients and significance of the firm-level variables and others do not change much, confirming that the environment in which the firm operates (i.e. country-level supply and demand conditions) matter for productivity of firms, as well as its size and financial health. While lagged values are not always the best instruments to use, in our case the first stage F-tests of the IV-regression confirm the relevance of our instruments and the Hansen J-test confirms the exogeneity of the instruments used.([39]) This suggests that using the lagged values as instruments here is not too bad an approach.

In the regression we also follow Manova (2012) by including interaction terms between credit conditions and asset tangibility, where we define the latter at sector-level and averaged over time to avoid endogeneity. This interaction is telling us that average productivity levels are substantially lower in sectors that intensively use fixed tangible assets.

([39]) A first stage F-test above 10 is considered to be an indication that instruments are relevant and as such correlate sufficiently with the endogenous variables. A p-value above 10 % is considered to indicate that instruments are sufficiently exogenous and do not correlate with the error terms.

When allowing for a double interaction with the crisis dummy, it becomes clear that while high collateral sectors have lower productivity levels, this effect was reduced during the crisis. This seems to suggest that when bank financing becomes more tight and selection criteria are stricter (Table II.1.2) that collateral may actually help firms to overcome stricter selection rules when applying for credit. A second interaction introduced by Manova (2012) is one between the financial credit supply conditions of a country and reliance on external capital to finance activities. This vulnerability to external capital is again defined at sector level to avoid endogeneity. The information on sector vulnerability is a cross-sectional variable without time variation. The interaction "credit supply x vulnerable sectors" shows a positive and significant result suggesting that especially for firms that rely more on outside financing, the availability of credit supply is important to allow them to reach higher productivity.([40]) When taking a double interaction with the crisis dummy, we observe that vulnerable sectors were not more than other sectors negatively affected by the crisis, which is re-assuring. The results obtained here by and large confirm the results of Manova obtained on US firms. It can be noted that because the asset tangibility (collateral) and external financial dependence (vulnerability of a sector) are non-time varying variables, we can only include them in the interaction terms but not separately in the regressions, since they would drop out as we also include sector-level fixed effects.

Most regressions are run with country fixed effects and sector fixed effects which control for all omitted variables in the model that vary at country and sector level (but not over time).

The value of the coefficient on the crisis dummy is about the same in the first four columns but seems to increase in the last three columns of Table II.1.2. The simple explanation for this is that from column (5) in addition to including the crisis dummy separately we also include the crisis dummy in interaction terms. As such, the coefficients on the separate crisis dummy cannot simply be compared between the regressions without and with interaction terms. Without

([40]) This result for firm-level data also applies when using industry-level data as in Chapter 3 in part II in this volume.

interaction terms, the crisis dummy coefficient reflects an average effect across all firms, sectors and countries. With the interaction terms, the crisis dummy coefficient represents an average effect for firms that belong to a certain group i.e. the firms that remain when the interaction terms are zero.([41])

When instead of sector fixed effects we include firm-level fixed effects as we do in column (6) of Table II.1.2, the overall variability explained by the model goes up but results on individual variables remain qualitatively the same. When we include the firm fixed effects we leave out the firm-level variables financial health and size which are likely to be correlated with the firm dummies and their time variation is likely to explain little additional variance. The goodness-of-fit of the model is not very high, which is typically the case when using firm-level variables. The best fit is obtained with firm fixed effects resulting in an R-squared of 68 %.

1.4.6. Regressing macro-level financial indicators on firm-level exporting status

The results of the cross-sectional exporters regression are reported in Table II.1.3. EFIGE data hold survey information about a firm's exporting status in the year 2008. Thus, we will first estimate the model as a cross-sectional regression based on one year, and then use the obtained regression coefficients to make out-of-sample predictions about the likelihood of exporting of firms in earlier and subsequent years. This is possible since the regressors that we are including in the cross-sectional exporters model are time varying (covering the 2001-2011 period).

In line with the literature we expect exporting to be driven by firm-level productivity and size. Indeed when including both productivity, employment, financial health and age as explanatory variables we see that their sign is positive and that they are very significant in any specification that we present in Table II.1.3. In the probit regressions we include these firm-level regressors of the year 2005 (i.e. preceeding the year in which we have information on export status by three years) to avoid endogeneity. Results show that the probability to export rises when firm productivity increases, when firms are older, larger and more financially healthy. These results are confirmed in an IV regression in which we instrument all the firm-level regressors with their lagged values in 2005 and 2001. First stage F-statistics suggest that instruments are relevant and the Hansen J-statistic confirms the exogeneity of the instruments.

The fact that financial health at firm-level is important to explain exporting status of a firm corresponds with the findings of Antras and Foley (2011), who show that especially in "civil law" countries, a cash advance is very common in trade contracts. Here we find that a good cash position is important to explain the exporting status and since we know from EFIGE that exporting firms are also often importing firms, the cash position of a firm appears to be an important element to facilitate trade both on the importing and exporting side.

A surprising but robust result that we find is that credit supply conditions have little direct impact on the exporting decision of firms. In other words, the financial environment at country-level in which the firm operates does not seem crucial for its exporting decision. The exporting decision seems to depend much more on the firm's own conditions such as how productive it is, its size and financial condition. Thus, while the credit supply environment appeared an important determinant for average firm-level productivity (as shown in Table II.1.2), and as such affects the export participation decision indirectly, this no longer is the case when directly including it in the export equation. This suggests that bank financing is critical for a firm to achieve a certain productivity level. The absence of sufficient financing can potentially act as an impediment to growth. But financing appears less of an obstacle whenever a firm wants to take its activities to a next level by engaging in exporting. Thus the firm appears less dependent on the country-level institutional environment in terms of financial development and credit supply once a firm has reached a sufficiently high productivity level.

These results need not be in contrast with earlier findings in the literature. Currently, there is a growing literature on the link between financing and trade and results highly depend on the specific research question. For example, Amiti and

([41]) The interpretation of the coefficient on the crisis dummy in the presence of interaction terms also using the crisis dummy is not straightforward and lies outside our interest here.

Weinstein (2012) find that a decline in the financial health of a firm's bank is associated with a decrease in its exports. But Levchenko et al. (2010) find that financial considerations play no role in understanding trade flows during the crisis. These studies differ in two important aspects from ours. Amiti and Weinstein (2012) use data on firm-bank specific relationships over time, which we do not have here. Our measure of credit supply is a much more aggregate one and refers more to the "country-level" financial conditions that a firm is operating in. Second, and more importantly, this earlier study investigated the intensive margin of exports over time, while in our study we consider the export market participation in a cross-section. The research question is therefore very different. In earlier studies the question was whether, *amongst exporting firms*, the ability to increase export market shipments depends on the health of the bank in the firm-bank relationship, thus comparing exporting firms with other exporting firms but with varying degrees of their individual banking health during the crisis. In this chapter, the research question is about *exporting firms to non-exporting firms*, and to see to what extent country-level credit conditions and institutions can explain the number of exporting firms in each country. There we come to the conclusion that, controlling for the productivity of firms (and for the effect credit supply has on productivity), the average health of the country-level banking sector does not directly impact the number of exporters much. Clearly, more research is needed to straighten out better and summarize the different results depending on the research question and data at hand. Future research on the intensive margin of exports during the crisis would therefore be complementary to this study.

While we would like to include a measure of demand abroad, by including the log of EU GDP, we cannot do this in our cross-section since this variable would not vary over EU firms and would drop out in the regression.

A very different (and robust) result is obtained when considering the importance of domestic demand. All the regressions appear to suggest that domestic demand is crucial in explaining the export participation decision. Surprisingly, the relationship is a negative one which can only be understood as the result of crowding-out. Put differently, in the event of a downturn in domestic demand, firms are more likely to engage in exporting. But when domestic demand is strong at home, the export probability of firms appears to go down. In fact this results is quite intuitive in the light of the observation that countries with large domestic markets typically have less exporters. Indeed whether firms have an incentive to engage in exporting or not, appears to be largely driven by country-level domestic market conditions.([42])

The coefficients of the IV-regression model in column (6) can now be used to generate out-of-sample predictions about the probability of exporting. We have information for all the regressors between 2001-2010. Thus by multiplying the regression coefficients from the model in (6) with these time-varying variables, we can obtain predicted probabilities of exporting. We limit this exercise that we perform here to verifying whether the average probability of exporting in years before 2008 is lower or higher than the average probability of exporting in years after 2008 (where we do not include 2008 itself). Subsequently we run a t-test on the difference of means to establish whether average exporting probabilities have gone significantly up or down.

There are several opposing forces at work in the model. First, we see that the evolution of firm productivity as displayed in Graph II.1.1 has gone down which results in a lower probability of exporting after 2008. However, this is offset by the fact that domestic demand and consumer sentiment in Europe on average decreased substantially after 2008, which induced firms to try and expand their sales by selling abroad. This downturn of domestic demand has had an upward effect on the probability to export that offsets the reduction in average firm productivity, ultimately rendering the probability to export for EU firms in our sample higher than before the crisis.

1.5. DISCUSSION OF RESULTS

In this section, we focus on the interpretation of results in light of other results obtained in the

([42]) This complements the European Competitiveness Report, 2012, which states that the *amount of* exports (how much) depend on demand conditions abroad, whereas here we find that based on micro-level data, firms' incentive to *participate in* export market (exporting or not) relies on country-level domestic demand evolutions.

Table II.1.2: **Productivity levels of EFIGE firms (TFP- Levinsohn-Petrin) and financial conditions**

Dependent: ln TFP, *ft*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ols	ols	ols	ols	ols	ols	ivregress
crisis_dummy,*c*	-0.085***	-0.06***	-0.07***	-0.06***	-.16***	-0.20***	-.18***
	(23.77)	(13.85)	(16.82)	(8.32)	(8.32)	(13.34)	(9.25)
credit_supply,*ct-1 (factor)*		0.02***	0.009**	0.05***	.07***	0.044***	.03***
		(6.32)	(1.96)	(14.02)	(4.59)	(4.65)	(2.46)
domestic_demand,*ct-1 (factor)*		.018***	0.027***	0.03***	0.05***	0.03***	.04***
		(7.01)	(8.21)	(10.13)	(5.81)	(6.28)	(6.18)
ln EU gdp,t-2			.068***	0.02	0.05*	0.68***	0.16***
			(8.09)	(1.51)	(1.83)	(3.09)	(6.12)
financial_health,*ft-2 (factor)*				0.09***	.10***		0.10***
				(43.20)	(21.3)		(16.49)
lnEmploym,*ft-1*				0.11***	0.10***		.12***
				(38.20)	(12.50)		(12.50)
credit_supply, *ct* x Collateral, *s*					-8.07***	-5.24***	-6.70***
					(9.17)	(9.01)	(8.20)
credit_supply, *ct* x Collateral, *s x* crisis_dum					1.22***	1.40***	0.84*
					(2.56)	(3.09)	(1.74)
credit_supply, *ct* x Vulnerable, *s*					5.3***	5.74***	4.5***
					(7.42)	(10.05)	(6.14)
credit_supply, *ct* x Vulnerable, *s* x crisis_dum					0.39	0.47*	.55*
					(1.38)	(1.86)	(1.91)
Constant	0.09	0.09	-2.01***	-1.49*	-1.81*		-5.4***
	(1.30)	(1.32)	(4.7)	(1.97)	(1.87)		(6.01)
cluster on firm identifyer	YES	YES	YES	YES	YES	YES	YES
country dummies	YES	YES	YES	YES	YES	YES	YES
sector dummies (2 digit)	YES	YES	YES	YES	YES		YES
sector dummies (4 digit)						YES	
firm FE						YES	
observations	80 508	53 148	53 148	24 621	18 026	38 201	14 026
R-squared	0.08	0.08	0.08	0.26	0.28	0.68	0.26
Hansen J test of Identification							p=0.51
First stage F-test for instruments							
lnemp							835
financial_health							391

(1) t-values between brackets. *** significance at 1 percent; ** at 5 percent; * at 10 percent. Subscript f:firm; s:sector; c:country; t:time. In (7) lnemp and financial_health were instrumented with t-1 and t-2 values as well as with 2001 values
Source: See Appendix A for data sources

literature. We discuss those results that confirm earlier studies, but focus even more on the results that are new to the literature and that could be relevant for policy.

Our findings suggest that for firms to reach a high productivity level and to grow, the financial conditions that surround them are quite important. Thus, there is a role for the institutional framework here since we clearly see that in countries with highly developed financial systems and favourable credit supply conditions, firms do better in terms of average productivity levels, especially in sectors that heavily rely on outside capital.

This can be interpreted in the following way. When a country has a well-functioning banking sector with high returns-on-investments and with few non-performing loans, this is a necessary condition for firms to become more competitive and productive. A well-functioning banking sector is more likely to recognize viable business projects and spot firms that are likely to pay back their loans. This is likely to result in more credit to "good" firms and less credit to "bad" firms, which will allow good firms to grow faster and average productivity to be higher than in countries where banks are less equipped to distinguish between firms. Our finding that domestic country-level credit conditions matter for productivity and growth also suggests that firms initially turn to local banks and seek financing nearby which makes them vulnerable to the local credit conditions.

However, when it comes to the exporting decision, our findings show that country-level credit supply conditions and the quality of the financial sector appears to play a much smaller direct role in affecting exporting decisions. A prerequisite for exporting thus appears to be a high productivity level, sufficient size and a good financial

Table II.1.3: **Cross-section exporters probability of EFIGE firms (TFP- Levinsohn-Petrin) and financial conditions**

Dependent: Prob (Exp=1) in year 2008	(1)	(2)	(3)	(4)	(5)	(6)
	probit	probit	probit	probit	probit	IV regres
lnTFP_2005, *f*	.173***	.073***	.066***	0.08***	.083***	.084***
	(21.30)	(8.30)	(7.35)	(7.95)	(4.98)	(3.12)
lnEmploym_2005, *f*		.143***	.132***	.13***	.10***	.10***
		(37.26)	(34.57)	(30.68)	(15.47)	(12.14)
lnage,*f*			.092***	.096***	.10***	.10***
			(17.58)	(13.52)	(10.23)	(10.66)
credit_supply,*c (factor)*				.017	.011	.026
				(0.79)	(0.37)	(0.83)
domestic_demand,*c (factor)*				-.107***	-.113***	-.111***
				(9.97)	(7.57)	(15.91)
financial_health_2005,*f (factor)*					.022***	.024***
					(4.39)	(4.17)
country dummies	YES	YES	YES	YES	YES	YES
sector dummies (2 digit)	YES	YES	YES	YES	YES	YES
sector dummies (4 digit)						
observations	26 464	26 464	26 464	22 000	12 030	7450
R-pseudo	0.1	0.14	0.15	0.18	0.15	
R-squared						0.2
Log LR chi 2 (29)	3832.56	5337.32	5626.84	4967	2454	
LL-Ratio	-16419	-15667.24	-15494	-12762	-7099	
Wald chi2 (30)						3572
Durbin_Wu Hausman test						p=0.0006
first stage F-tests lnTFP						350
first stage F-tests lnEmploym						1926
first stage F-tests financial health						261
Hansen J-test for underidentification						p=1.789

(1) t-values between brackets. *** significance at 1 percent; ** at 5 percent; * at 10 percent. In (6) we instrument lnTFP, lnEmploym, financial_health in 2008 with their values in 2005 and 2001
Source: See Appendix A for data sources

condition, but exporting relies much less on domestic country-level credit supply conditions. When firms reach high productivity and sufficiently large size, they appear to become much less reliant on local credit conditions which may point at the fact that this is no longer an impediment to their plans of selling abroad. The finding that older firms have a higher chance of export market participation also suggests that exporting is often a strategy that firms engage in later in their life.

Thus, we can tentatively conclude from this study that local financing conditions predominantly seem to matter in the early stages of a firm's life i.e. when the firm needs financing to grow and to become more productive. It is in this phase that firms are most vulnerable and most affected by the credit conditions set locally. Later in their life, when they have become sufficiently strong, local credit conditions act much less as an impediment to further develop their activities.

Local demand conditions appear critical to explain export market participation. The relationship is a negative one. During a downturn of the domestic market, firms are more likely to be exporters than in booming domestic markets. Put differently, when there is a domestic market loss and firms can no longer sell as much locally, this raises their probability of engaging in exporting, while in demand booms they are more likely to sell at home.

This new result can also shed an interesting view on the current account. Typically a current account surplus is associated with competitive countries and productive firms, but what our firm-level results are showing is that it can also be a reflection of a shrinking domestic demand.

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ANNEX 1
Appendix A: Data & data sources

Table II.A1.1: **Country-level Macro Series**

Supply side	Source
● Non-performing loans	INDICSER (2001-2011)
● Exposure of banks to foreign high risk claims to assets issued by Greece, Ireland and Portugal as a percentage of total bank assets	INDICSER (2001-2011)
● Loans to enterprises	Bank Lending Survey (2007-2011)
● Net percentage of banks that tightened their credit standards	Bank Lending Survey (2007-2011)
● Loan applications success/failure	SAFE dataset (2009-2012)
● Return on equity of banks	Bankscope data (2001-2012)
● Credit/GDP ratio, i.e. "private credit by deposit money bank as a share of GDP"[1]	World Bank data, Beck (2012) for 2001-2010
● Bank concentration in a country, i.e. "assets of the three largest banks of a country as a share of assets of all commercial banks of that country"	Beck (2012) for 2001-2010
Demand side	
● Consumer confidence indicator	European Commission (2003-2013)
● Economic sentiment indicator	European Commission (2003-2013)
● Unemployment rate	Eurostat (2001-2013)
● Changes in demand for loans to enterprises	Bank Lending Survey (2003-2013)

Source: Indicated in the second column

Table II.A1.2: **Sector-level**

Data	Source
Asset tangibility of sector i.e. tangible fixed assets as a share of total firm assets	EFIGE data merged with AMADEUS
Financial vulnerability i.e. share of capital expenditure of firms not financed with cash flows from operations	Manova (2012)

Source: Indicated in the second column

Table II.A1.3: **Firm-level**

Data	Source
Indebtedness, i.e. non-current liabilities/total assets	EFIGE data merged with Amadeus
Cash flow	EFIGE data merged with Amadeus
Interest repayment ability, i.e. cash flow/interest paid	EFIGE data merged with Amadeus
Age	EFIGE data merged with Amadeus
Sales	EFIGE data merged with Amadeus
Crisis dummy	Assuming a value of "1" in years from 2008 onwards

Source: Indicated in the second column

Box II.A1.1: **Appendix B: Total Factor Productivity method of Levinsohn and Petrin (2004)**

Assume a Cobb-Douglas production function of the form:

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_m m_t + \omega_t + \eta_t$$

and let y_t be the log of a specific firm's output. In our production function:

- l_t and m_t denote the labour and intermediate inputs in log terms (freely available), respectively
- k_t is the logarithm of the state variable capital
- η_t is the component of the error term uncorrelated with input choices
- ω_t is the component of the error term representing a productivity shock unobserved by the econometrician, but observed by the firm.

The reason why a simple OLS estimation cannot be used in order to estimate the production function is that the firm adapts its input choice as soon as it observes ω_t, therefore inputs turn out to be correlated with the error term of the regression, yielding to inconsistent OLS estimation as far as production functions are concerned.

Levinsohn and Petrin (2004) (LP) propose a correction for this issue. Assuming the demand for intermediate inputs m_t (e.g. material costs) to depend on the firm's capital k_t and productivity ω_t, the authors show that the same demand is monotonically increasing in ω_t. This allows to express the ω_t in terms of capital and intermediate inputs, in other words, we can write $\omega_t = \omega_t(k_t; m_t)$, where remind that ω_t is unobserved while k_t and m_t are observable.

In order to identify ω_t, LP follow Olley and Pakes and assume ω_t to follow a Markov process of the form $\omega_t = E\left[\omega_t|\omega_{t-1}\right] + \epsilon_t$, where ϵ_t represents the change in productivity uncorrelated with k_t. This assumption makes it possible to rewrite the production function as:

$$y_t = \beta_l l_t + \phi(k_t; m_t) + \eta_t$$

Where $\phi(k_t; m_t) = \beta_0 + \beta_k k_t + \beta_m m_t + \omega_t(k_t; m_t)$.

Substituting a third-order polynomial approximation in k_t and m_t in place of $\omega_t(k_t; m_t)$, LP show that it is possible to consistently estimate the parameter $\widehat{\phi_t}$ and $\widehat{\beta_l}$ in the equation above.

(Continued on the next page)

Box (continued)

For any candidate value β_k^* and β_m^* one can then compute a prediction for ω_t for all periods t, since $\widehat{\omega_t} = \widehat{\phi_t} - \beta_k^* k_t - \beta_m^* m_t$ and hence, using these predicted values, estimate $E[\omega_t|\widehat{\omega_{t-1}}]$. It then follows that the residual generated by β_k^* and β_m^* with respect to y_t can be written as:

$$\widehat{\eta_t + \epsilon_t} = y_t - \widehat{\beta_l}\, l_t - \beta_k^*\, k_t - \beta_m^*\, m_t - E[\omega_t|\widehat{\omega_{t-1}}]$$

The equation above can be used to identify β_k^* and β_m^* using two instruments:

- assuming that the capital stock k_t is determined by the previous period's investment decision, it then does not respond to shocks to productivity at time t and hence $E[\eta_t + \epsilon_t|k_t] = 0$;
- assuming the last period's level of intermediate input m_t to be uncorrelated with the error term at time t (which is plausible, e.g. proxying intermediate inputs with material costs), then $E[\eta_t + \epsilon_t|m_{t-1}] = 0$.

Through these two moment conditions, it is then possible to write a consistent and unbiased estimation for β_k^* and β_m^* by solving:

$$min_{(\beta_k^*, \beta_m^*)} \sum_h \left[\sum_t (\widehat{\eta_t + \epsilon_t}) Z_{ht}\right]^2$$

with $Z_t = (k_t, m_{t-1})$ and h indexing the elements of Z_t.

This algorithm is implemented by Stata which automatically calculates this semi-parametric derivation of TFP.

Source: Altomonte, Aquilante and Ottaviano (2012).