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1 April 2014

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Abstract

In this paper we provide original findings on the impact of local financial development (LFD) on manufacturing firms' energy intensity in European and Central Asian (ECA) post communist countries. We implement the two-step method of Guiso et al. (2004) in order to build a lagged measure of financial development at the local level. The paper is the first to use this methodology to assess local financial development in the ECA region and to test its effect on firm-level energy demand. According to related literature, our findings also show that firm size matters. But we also provide a new insight about the non-linear effect of financial development depending on the scope of the financial market. We show that while energy consumption of small businesses is more affected by local financial markets, large firms are more sensitive to countrywide financial in-depth. Overall, this paper provides econometric evidence for a financial access explanation of the "energy efficiency gap". Improving financing opportunities should increase firms' energy efficiency. Moreover, focus on local conditions and small firms should be an important feature of active energy-saving financial policies.

JEL: Q4, D21, P28
Keywords: Energy Intensity, Local Financial Development, Firm Size, ECA Region

*We thank Jean-Louis Arcand, Jasna Atanasijevic, Pierre Blanchard, Stéphanie Mahieu, Mathilde Maurel, Julie Lochard and Richard Pomfret for very helpful comments. All errors remain ours.

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1 Introduction

The narrow and ongoing issue of medium and long-term economic sustainaiblity put energy efficiency at the top of the policy agenda for the next decades. Not only for environmental and health priorities but also for the competitiveness of firms. The energy related problematic is especially important for the region going from Central Europe to Central Asia. Economic agents inherited energy inneficient structures and behaviors, and as a consequence ECA countries use on average twice more energy to produce each unit of GDP than the industrialised countries group. As expressed in Table I, in 2007 even comparing to a sample of emerging countries, transition economies are by far the most energy intensive. Margins to modernise productive assets in order to improve energy performances are substantial. In this way, the impact of financial access on firms' energy intensity should be of a sizeable magnitude and should be able to fill, at least partly, the energy intensity gap between transition and industrialised countries.

Table I: Energy Intensity in Selected Groups of Countries, in 2007

	Mean	Std. Dev.	Minimum	Maximum	N
Industrialised	137.6	68.8	49.7	426.1	27
Emerging	178.5	65.5	68.2	297.2	19
Transition	260.4	161.5	101.8	791.3	25

Energy intensity is expressed as energy consumed in kilotonnes of oil equivalent per constant 2000 US$, values are averaged over country groups. List of countries is displayed in table A1. Source: World Development Indicators, World Bank.

Does local financial development influence energy intensity? The "energy efficiency gap"[1] literature suggests that limited external access to capital should constrain firms' ability to undertake energy efficiency projects (DeCanio, 1993). In a purely competitive context, if all economically profitable investment opportunies can be financed, then firms' energy consumption should be at an economically optimal level. But if access to financial funds is limited, and when information is not perfect, firms must therefore make a trade-off between several investment projects, thus constraining energy-saving investments. Lack of capital limits funds to be devoted to energy efficiency measures, which are furthermore considered low on the priority list by managers. Potential financial barriers may explain, at least partly, the "gap" between cost-effective energy efficient investments and the level of such investments actually implemented. The issue of economic sustainability as well as the rising energy cost in the current worldwide context of financial shortage, make this question of a crucial and growing importance.

Since the work of Demirgüç-Kunt and Maksimovic (1998), an extensive empirical

[1] The term of "energy efficiency paradox" can also be found in the literature, see for exemple Martin et al. (2012).

literature has discussed whether financial development affects various aspects of firm-level performances. Evidence has shown that financial access improves firms' probability to emerge, to grow, to invest, to innovate and to export (Guiso et al. (2004), Beck and Demirgüç-Kunt (2006), Guariglia (2008), Gorodnichenko and Schnitzer (2010) among others). Yet, to the best of our knowledge, no econometric studies has focused on firms' energy performance related to wider financial access.

This paper aims to fill this gap by questioning whether or not local financial access is important for manufacturing firms' energy intensity in the ECA region. For this purpose, we update the seminal two-step method developed by Guiso et al. (2004) to build-up a lagged measure of financial development at the local level. We estimate a local financial access indicator using data from the Business Environment and Enterprise Performance Survey (BEEPS) of 2002 and 2005 to explain firm energy intensity in 2007. We provide an original finding that energy intensity of firms located in financially well developped regions is significantly lower. We check for the robustness of our results, using alternative specifications, regional fixed effects and instrumental variables. Consistent with related litterature, our findings also show that the firm size matters. While affecting all firms, the *local* financial development effect on energy intensity is lower as firm size increases. In contrast, the *country* financial development has a stronger impact on energy consumption of larger firms. Overall, this paper provides econometric evidence for a financial access explanation of the "energy efficiency gap" in the particular case of the post-communist countries.

Starting with King and Levine (1993), a large body of the literature shows that cross-country financial development heterogeneity matters for economic performance. However, within-country variation of financial access has attracted less attention. Overall evidence of papers dealing with this issue strongly supports the role of local financial development. Thus, Jayaratne and Strahan (1996) and Dehejia and Lleras-Muney (2007) provide evidence that cross-state variation in banking regulation fosters state-level growth within United States. Guiso et al. (2004) and Hasan et al. (2009) find a positive impact of local financial development and efficiency in countries inside the European Union (EU). And finally, Kendall (2012) and Fafchamps and Schündeln (2013) show positive growth impact of regional banking depth in two developing countries, India and Marocco respectively. But, our paper is the first to analyse the role of regional financial development over ECA countries.

Sub-national financial development focus is relevant only in the case where physical distance between lenders and borrowers may segment local financial markets. As documented by Peterson and Rajan (2002) and Bofondi and Gobbi (2003), due to transaction costs and assymetric information, distance is likely to affect access to finance. Peterson and Rajan show that, even in the United States, the distance between small firms and their banks matter for the provision of banking funds. From the quoted literature and previous evidence about the

role of local financial markets, we expect to find significant variation in regional financial development across our sample. Indeed, distance between lenders and borrowers can make borrowers' screening and monitoring harder and thus may lead to adverse selection and moral hazard. And these issues should be of great importance as the ECA region displays lower levels of development and financial integration comparing to the US or EU-15 member states.

Another important feature of the local financial development should be its potential non-linear effect. Indeed, if local conditions matter, its consequences should be lower for *a priori* less financially constrained firms. Petersen and Rajan (2002) and Berger et al. (2005) provide evidence that small businesses are more dependent on local financial markets because they are less prone to borrow when lenders are far apart. This evidence is pointed out by Guiso et al. (2004) and Fafchamps and Schündeln (2013). In accordance with these papers, we test the assumption that effect of local financial development on energy intensity is decreasing with firm size. But the coverage of our sample allows us to go deeper in the analysis and to provide a new insight for the non-linear financial development effect. We test whether large firms are more able to seize broader (countrywide) financing opportunities than do smaller businesses.

This paper contributes to the existing literature in three improrant ways. First, to our knowledge we are the first to examine energy intensity in ECA countries using large manufacturing firm-level data. Second, we provide original econometric evidence that improvements of firms' energy use may be stimulated through better financial development. Morevover, we show that effet of financial access depends on the firm size and the scope of the financial market. Finally, our paper contributes to the small but growing literature on *local* financial conditions. It is the first to focus on ECA countries and unlike previous literature, we can directly examine the importance of *local* financial markets against *country* financial supply.

The rest of the paper is organised as follows. Section 2 develops the econometric model and presents the data. Section 3 explains in detail the construction of our variable of local financial development. Section 4 discusses extensively our econometric results. Finally, Section 5 concludes and proposes policy recommendations.

2 Econometric Framework and Data

In this section we start first by setting a firm cost function. Then, under the assumption of cost minimisation and applying Sheppard's lemma, we derive an equation of energy intensity. Finally, we present the data used for our empirical estimations. We want to look at the differences in energy intensity between

firms facing different local financial access. We first need to set the theoretical framework of our energy demand model, before presenting strategy used to build our indicator of local financial development (Section 4) and analyse the estimation results (Section 5).

For the purpose of our empirical question, following a rather standard approach, we adopt the translog theoretical factor demand framework (Christensen et al., 1973). We assume that a firm's technology can be described with a variable (or quasi-fixed) cost function (see Brown and Christensen, 1981) given only by the cost of energy and intermediate materials, while capital and labour are assumed to be quasi-fixed factors. Assuming labour as quasi-fixed seems adequate and fitting in this case.[2] Our choice is motivated by market and out-of-market rigidities observed in the former Soviet bloc countries (Rutkowski, 2007). Moreover the labour quasi-fixity is in line with large labour hoarding and the very slow unemployment decrease in these countries during the last decade, despite sustained growth performances since the 2000'. But relaxing this assumption does not significantly affect the result of our variables of interest. We also have considered labour as a variable input. Including the firm's average wage as a labour price in our equation does not change our main result, whereas the labour price elasticity provides an incoherent sign for a variable input.[3] Therefore, the restricted cost function of a firm i takes the following form:

$$\begin{aligned}
\ln C_i(w_i^a, Y_i, K_i, L_i) &= \ln \alpha_0 + \sum_a \alpha_a \ln w_i^a + \sum_a \sum_b \alpha_{ab} \ln w_i^a \ln w_i^b \\
&+ \alpha_Y \ln Y_i + \sum_a \alpha_{aY} \ln w_i^a \ln Y_i \\
&+ \alpha_K \ln K_i + \sum_a \alpha_{aK} \ln w_i^a \ln K_i \\
&+ \alpha_L \ln L_i + \sum_a \alpha_{aL} \ln w_i^a \ln L_i \\
&+ \alpha_B B_i + \sum_a \alpha_{aB} \ln w_i^a B_i \qquad (1)
\end{aligned}$$

where $a, b \in \{E, M\}$ index energy and materials variable production factors, w_a represents factor price for input a, Y is gross output, L and K are respectively labour and capital fixed inputs. The term B is supposed to capture an energy bias in the firm's production technology.

The homogeneity restrictions allow normalization of the translog cost function by one of the factor prices. For simplicity purposes, we normalized the cost

[2] Even less usual, considering labour as a quasi-fixed input is not new (Oi, 1962). Morrison (1988) provides an applied example with labour and capital as quasi-fixed factors, but in the case of a generalized Leontief restricted cost function. Some papers as Cole et al. (2008), Bloom et al. (2010) and Morikawa (2012), also make an assumption of labour fixity even if it is not explicitely specified.

[3] Results are available upon request.

function using materials price as the numeraire in (1):[4]

$$\begin{aligned}\ln C_i(\frac{w_i^E}{w_i^M}, \frac{Y_i}{w_i^M}, \frac{K_i}{w_i^M}, \frac{L_i}{w_i^M}) &= \ln \alpha_0 + \alpha_E \ln \frac{w_i^E}{w_i^M} + \alpha_{EE} \ln \frac{w_i^E}{w_i^M} \ln \frac{w_i^E}{w_i^M} \\ &+ \alpha_Y \ln Y_i + \alpha_{EY} \ln \frac{w_i^E}{w_i^M} \ln Y_i \\ &+ \alpha_K \ln K_i + \alpha_{EK} \ln \frac{w_i^E}{w_i^M} \ln K_i \\ &+ \alpha_L \ln L_i + \alpha_{EL} \ln \frac{w_i^E}{w_i^M} \ln L_i \\ &+ \alpha_B B_i + \alpha_B \ln \frac{w_i^E}{w_i^M} B_i \qquad (2)\end{aligned}$$

Demand for energy input, applying Shephard's Lemma, is given by the cost share of energy: $s^E = \frac{\delta \ln(\frac{C}{w^M})}{\delta \ln(\frac{w^E}{w^M})}$. Differentiating (2) with respect to the relative price of energy provides the following energy intensity equation:

$$s_i^E = \alpha_E + \alpha_{EE} 2 \ln \frac{w_i^E}{w_i^M} + \alpha_{EY} \ln Y_i + \alpha_{EK} \ln K_i + \alpha_{EL} \ln L_i + \alpha_{EB} B_i \qquad (3)$$

To test wether firm-level energy intensity is related to financial access, we will allow the energy bias term to vary with our indicator of local financial development. We also use macroeconomic indicators of financial development to ensure the adequacy of the highlighted effect and to override the problem of identification of our "local" variable.

We assume that relative factor price will be accounted by industry and country fixed effects. Therefore, the most general stochastic form we use is as follows:

$$s_i^E = \alpha_E + \alpha_{EY} \ln Y_i + \alpha_{EK} \ln K_i + \alpha_{EL} \ln L_i + \alpha_{LFD} LFD_x + \alpha_Z Z_i + \epsilon_i \qquad (4)$$

where LFD_x is the indicator of local financial development in region x, and we anticipate its coefficient to be negative. Z is a set of further controls including firm control variables and industry and country dummies. We expect to find positive coefficients of capital and labour fixed inputs and negative coefficient associated with the coefficient of output, as firms should face economies of scale. The construction of our LFD variable is explained in Section 4.

Our dependent variable s_i^E is given by the share of energy expenditures over total variable cost.[5] We use firm-level cross-sectional data from the BEEPS jointly conducted by the EBRD and the World Bank in 2008-2009. The BEEPS contain

[4] See Adams (1999) for more details.

[5] Energy expenses are obtained by adding total annual costs of electricity and fossil fuel, whereas total variable cost also includes costs of raw materials and intermediate goods, communications services and water.

cross-sectional information on a representative sample of firms of Eastern Europe and Central Asia (29 countries in the last round). The survey covers a large set of topics, including corruption, access to finance, crime, justice and firm performances measures. Unfortunately, we cannot use previous rounds of the survey because they do not contain needed information about firms' energy expenses.

In table A2, we report summary statistics of the main variables used in our regressions based on the last round (2008-2009) of the BEEPS. The enterprise information concerns the year 2007. Using observations for which we have complete data, the final sample contains more than 1200 observations over 22 ECA countries. The list of countries is provided in table A1. Finally, several macroeconomic variables are used to control for potential nation-wide effects and are provided by WDI and EBRD transtion indicators.

We discuss in the next section the construction of our indicator of financial development at the local-level, before presenting in Section 4 estimation results based on equation (4).

3 Indicator of Local Financial Development

To examine the effect of financial access on firms' energy consumption, we focus on financial development at the local-level. We compute a local indicator by relying on firms' self-reported finacial access constraint. There are several advantages of using, in our regressions, a regional indicator of financial development, instead of the direct answer. First, companies whose report may be constrained by access to finance are more likely to need financing. This is generally the case for the most productive growing firms. And we can expect those companies to be more energy efficient. This implies a downward bias of the impact of access to financial markets on energy consumption, the less energy intensive firms declaring to be constrained by external funding needs. On the other hand, energy intensive firms might plausibly be less productive overall. If the financial market is able to detect firms' productivity levels, we can expect the less energy efficient firms to get a lower access to external finance. Uneasy access to financing is also more binding for small and younger firms. So, using the direct measure of access to financial markets implies restricting the analysis on small and young businesses, which are more energy intensive. The direct approach might therefore have an important endogeneity bias (downward and upward) with our dependant variable. Nevertheless, information reported by firms is still a valid measure of the variation of inter-regional access to finance. In addition, the database used to construct regional indicators is much larger, which enhances the quality of the estimated coefficients.

In order to build our local indicator of financial development, we follow a two step procedure inspired by the seminal paper of Guiso et al. (2004). Distinguishing differences in financial development between different regions of Italy, their paper highlights the positive impact of the development of local financial markets on several microeconomic variables (competition, entry of new firms, growth). This approach estimates regional financial development indicators by adding individual subjective assessments of financial obstacle in order to obtain regional scores. Normalizing those regional dummies allows to have a good proxy for regional financial development. We expect this measure to catch the ability of the local financial system to grant firms easier access to external finance. This method has been used by Villegas-Sanchez (2009) to highlight the role of local financial markets in externalities conveyed by foreign direct investments in Mexico. We assume that the financial access can be described by the following econometric equation:

$$FinancialAccess_i = \alpha_0 + \alpha_1 X_i + \gamma Region_k + D_j + D_t + \epsilon_i \tag{5}$$

where $FinancialAccess_i$ is a dummy variable denoting the financial access of firm i. This dummy equals to 1 if a firm reports that financial access is "no", "minor" or "moderate" obstacle to its current operations, and 0 otherwise ("very severe" or a "major" obstacle). The variable of interest is the set of region fixed effects $Region_k$, which should capture the financial development at the regional level. X is a vector of firm specific attributes that might explain the enterprise's response. In this last equation we also include year and 2-digit industry dummies respectively indexed by t and j. This allows us to control for unobserved year-specific and industry-specific factors that impact on the dependent variable.

To compute our indicator of local financial development we use the surveys of 2002 and 2005 of the BEEPS. In both surveys each firm is asked to rank to what extent financial access is a binding constraint for its current operations. Moreover, both surveys contain information about the region where is located each firm. This variable enables us to compute a local variable of financial development. An interesting characteristic of the BEEPS is that regions are used as strata in the sampling design, so surveys aim to be representative at the regional level. The geographical area of a given region is based on the first-level official administrative boundaries. When official boundary is too disaggregated, different administrative regions are grouped for stratification purposes of the survey. Each country is subdivided in six regions on average, from four regions in Slovenia to nine in the Czech Republic. Overall, the original sample contains 141 identified regions.

On average, each region contains over 80 observations.[6] It should be noticed that we limit our calculations to regions with a minimum of 20 observations in order

[6]Summary statistics at the regional level computed from BEEPS 2002 and 2005 rounds are available upon request.

to limit potential biases due to undersized regions. For the same reason we stack up the data from the 2002 and 2005 surveys. This aggregation seems fitting as there is no significant differences in the way both surveys were implemented. Table II provides firm-level descriptive statistics in both surveys as well as some regional statistics of the sampled firms. Overall, we can see in panels A and B that firms surveyed in 2002 and 2005 display similar characteristics. The only sizeable difference concerns the mean number of employees. It seems that in 2005 the surveyed firms are smaller on average. An important feature concerns the financial access dummy, which seems to be stable between 2002 and 2005.

Table II: Summary statistics

Panel A: firm level sample: BEEPS 2002					
	Mean	Std. Dev.	Minimum	Maximum	N
Financial access dummy	0.782	0.413	0	1	5810
Capacity utilization	80.408	20.062	1	100	6000
Number of employees	139.483	498.235	2	9960	6122
Firm age	14.701	18.703	3	202	6153
Exporter	0.243	0.429	0	1	6122
State ownership	14.887	33.908	0	100	5764
Foreign ownership	13.224	30.824	0	100	5770
Panel B: firm level sample: BEEPS 2005					
	Mean	Std. Dev.	Minimum	Maximum	N
Financial access dummy	0.775	0.418	0	1	9950
Capacity utilization	80.898	20.389	4	100	10278
Number of employees	95.114	341.439	1	9900	10073
Firm age	15.941	17.017	0	180	10409
Exporter	0.265	0.441	0	1	10408
State ownership	7.611	25.561	0	100	10421
Foreign ownership	8.238	25.33	0	100	10421

Panels A and B report summary statistics for firms surveyed respectively in the BEEPS 2002 and the BEEPS 2005 rounds. Financial access dummy equal to one if a firm reports that finance is "no", "minor" or "moderate" obstacle to its current operations, and zero otherwise ("major" or "very severe" obstacle). Capacity utilization is the share of the current output in comparison with the maximum output possible. Number of employees is the number of full-time employees. Firm age is the difference between the year a firm was surveyed and the year it began its operations in the surveyed country. Exporter is a dummy equal to one if a firm exports any output in a foreign country. State and foreign ownerships are a firm's percentages owned respectively by government/State and private foreign company(s).

We estimate in table III the response probability of the likelihood that access to finance is not a binding constraint for a company.[7]

[7] For ease of interpretation Guiso et al. (2004) have used linear probability models. But as we are not interested in the pure interpretation of this first step coefficients, but instead on

Table III: First Step Estimation of Individual Financial Access

Capacity utilization	0.006***
	(7.04)
Log number employees	0.083***
	(6.45)
Firm age	-0.001
	(0.73)
Exporter	0.020
	(0.44)
State ownership	-0.181***
	(2.92)
Foreign ownership	0.270***
	(4.46)
Region dummies	Yes
Year dummy	Yes
2-digit dummies	Yes
Observations	8,539
Pseudo R^2	0.099

The dependent variable is financial access dummy, equal to one if a firm reports that finance is "no", "minor" or "moderate" obstacle to its current operations, and zero otherwise ("major" or "very severe" obstacle). Capacity utilization is the share of the current output in comparison with the maximum output possible. Number of employees is the number of full-time employees. Firm age is the difference between the year a firm was surveyed and the year it began its operations in the surveyed country. Exporter is a dummy equal to one if a firm exports any output in a foreign country. State and foreign ownerships are a firm's percentages owned respectively by government/State and private foreign company(s). Region dummies are a set of dummies for each separate region where the surveyed firm is located. Reference region is Vojvodina, in Serbia, displaying the lower regional coefficient of financial access. Year dummy is a dummy equal to one if the year of survey is 2004. 2-digit dummies are industry dummies, disaggregated at 2 digits level. Standard errors reported in brackets are robust and clustered by country-industry. *, **, *** indicate significance levels of 10, 5 and 1%, respectively.

The econometric specification of the firm-level determinants of financial access is based on the paper of Beck et al. (2006). Our dependent variable is equal to 1 if the firm declares not to be constrained by the access to finance. We include industry dummies to control for sector-specific characteristics possibly influencing firms' financing access. Firms facing a more sustained demand, as captured by capacity utilization variable, seem to be less constrained by financial access. As expected, the number of employees enter significantly, larger firms report significantly higher financial access. The ownership structure seems also to be important in predicting firms' financing constraints. Foreign-owned companies report higher access to finance, while state-owned enterprises face lower access to finance. This set of results is consistent with findings of Beck et al. (2006). The only difference is that reported financing access does not seem to be significantly related to the age and the exporter status of the firm. But the result of the age variable, which has no significant effect, may be explained by poorer performances of firms created before the USSR collapse. In addition, to their control variables, we have included in our estimate regional dummies, capturing financial development differences across different regions inside each country.

Our variable of interest is *Region*. Indeed, the measure of local financial access will be the ranking provided by the coefficient γ of the region k. Regions where financial markets are more developed are those where access to market financing is easier. If local caracteristics of financial markets do not matter, then the probability to report a good financial access should not be significantly affected by regional dummies. Table IV shows the top ten (Panel A) and the lowest ten (Panel B) regions ranking according to their dummy coefficient estimate. Comparing to the reference region (Vojvodina, in Serbia) all other local dummies display a positive and significant coefficient.[8] This supports our assumption of wide cross-region differences in financial access across our sample. As highlighted in Panel A, regions with highest local financial system are located in EU zone, despite that estimations are driven on surveys conducted before the 2004 enlargement of the EU to the eight Central and Eastern European countries (CEEC) of our sample. Some countries, in particular Poland, display a lower financial development indicator than we would expect, thus indicating more difficult access to external funds by firms in these regions.[9] As shown in Panel B, the lowest finanically developed regions are located in Serbia, Georgia and Belarus. These countries are those which experienced the lowest financial depth and banking intermediation in the first half of the 2000' decade (see EBRD Transition Report 2012). Even if on average regions in EU show

the relative magnitude of these coefficients, we do prefer using a probit model.

[8]Except two of them (South East Serbia and Vitebskaya), which are not statistically different from Vojvodina at the usual significancy levels. Nevertheless, setting coefficients of these regions to zero does not change the magnitude or the statistical significance of our estimations.

[9]The study of Brown et al. (2006) also reports that over 24 transition countries, Poland has the lower ease of financing. Mainly because of low quality of the credit registry and low credit information sharing leading to a bad identification of risky loans.

slightly higher local financial development, the correlation is not very high (less than 0.3) implying that our estimated effect should not be uniquely driven by financial underdevelopment of non-EU zone compared to EU area.

We transform our regional coefficients into indicator varying between 0 and 1, indicating financial development. Therefore, to facilitate the interpretation, we normalize the regional dummy coefficients as follows:

$$LFD_k = \frac{\gamma_k}{max(\gamma_k)} \tag{6}$$

with LFD_k the Local Financial Development in region k and γ_k the coefficient of the region dummy k.

We build our local financial indicator using exclusively the BEEPS of 2002 and 2005 rounds. As there is a very small number of overlapping firms in the different rounds of this survey,[10] this allows us to compute a lagged indicator based on completely different set of observations. Another important advantage is that, compared to the 2008-2009 round of BEEPS, previous surveys are not affected by the global financial crisis started in 2007. Due to international financial contagion, the transmission of the crisis should be higher in regions where financial system is more integrated and/or vulnerable to international financial flows. In these regions, financial shrunk was probably felt as being the most severe. We want to examine the influence of an easier access to financial funds on energy intensity, and not the effect of efficiency or stability of local financial institutions. Taking into account the 2008-2009 round of BEEPS will alter our measure of local financial access with this last mechanism. This is an additional reason why we do not use in our regressions the direct individual answer about the financial constraint of firms. Using financial access information reported in previous surveys make our local financial development measure clean of a potential global crisis effect.

As LFD is estimated from a preliminary procedure, we need to ensure this variable complies with standard statistical properties. Thus, to make test statistics asymptotically valid in the second stage procedure, we need to compute an adjustment to the common variance matrix estimate that accounts for the variability in the estimated coefficients of the generated regressor (see Wooldridge, 2002, p.115-116). We use a popular resampling method, i.e. bootstrapping, for obtaining standards errors, confidence intervals and p-values for test statistics.

Before analyzing the results of our estimations, we look at the conditional distribution of energy intensity over our local financial development indicator. Figure I indicates the distribution of energy intensity for the lower values of financial development (the 25% of the worst financially developed regions) and the higher

[10] In our final sample, less than 1% of firms were surveyed in a previous BEEPS round.

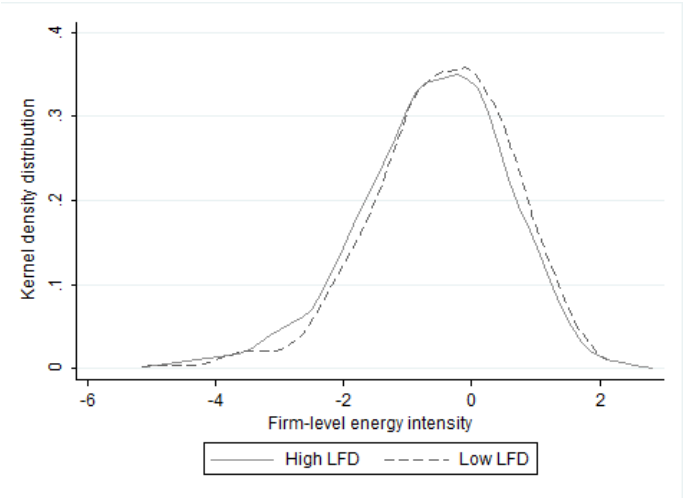
Table IV: Local Financial Development - LFD

Panel A: Top 10 LFD			
Region	Country	Regional dummy coefficient	Local Financial Development indicator
Stredne Slovensko	Slovakia	1.9565789	1
Ústecký	Czech Republic	1.8702239	.9558643
Slavonia	Croatia	1.8515556	.946323
Ural	Russia	1.8510218	.9460501
Zemgale	Latvia	1.7988949	.9194083
Volgo-Vyatskiy	Russia	1.7555416	.8972505
Riga	Latvia	1.7482936	.8935462
South West	Lithuania	1.7401197	.8893685
Bratislava	Slovakia	1.6728901	.8550077
Budějovický	Czech Republic	1.6495848	.8430964
Panel B: Lowest 10 LFD			
Region	Country	Regional dummy coefficient	Local Financial Development indicator
Eastern	Poland	.56113099	.2867919
Sud-Est	Romania	.51804234	.2647694
South	Ukraine	.48711365	.2489619
Belgrade	Serbia	.47592015	.243241
Southern	Poland	.45479062	.2324417
Central	Poland	.43259019	.2210952
Shida Kartli	Georgia	.19450514	.0994108
Vitebskaya	Belarus	.19297881	.0986307
South East Serbia	Serbia	.16503302	.0843477
Vojvodina	Serbia	0	0

The regional dummy coefficient is obtained from a probit estimation of the equation (5) using BEEPS 2002 and 2005. The Local Financial Development indicator is the normalized measure of financial development computed as in (6). Panel A shows the ten regions displaying highest coefficients for financial access estimation, whereas Panel B shows the ten regions with the lowest coefficients. Regions are ranked in the descending order.

values of financial development indicator (the 25% of the most financially developed regions). We can clearly see that the kernel distribution of energy consumption for the quartile of the less financially developped regions shifts on the right side compared to more financially developped regions. Overall, this figure shows that energy intensity is lower when the local financial access is higher. In the next section (Section 4), we examine extensively our econometric results on the link between local financial development and firms' energy intensity.

Figure 1: Energy intensity (log deviation from industry mean) and local financial development



Firm-level energy intensity is expressed as the log deviation from industry (2-digit) mean value. "LFD" is our normalized measure of financial development by region, over the period 2002-2005 (cf. Section 4). The figure displays the kernel density plots of energy intensity, expressed as energy cost over total variable cost, for the sample of firms with local financial development (LFD) at the top quartile (more financially developed regions) and in the lower quartile (less financially developed regions).

4 The Role of Local Financial Development on Energy Intensity

In this section, we discuss in details our regression results, corresponding to Tables 5 to 8. We first present our benchmark regression and test the impact of Local Financial Development (LFD) on manufacturing firms' energy intensity(4.1). In the following subsection (4.2), we investigate whether firm size matters. In the third subsection (4.3), we present the country financial development and how it affects the energy intensity. In the last two subsections,

we do some robustness checks: changing our baseline specification (4.4), introducing regional fixed effects and controlling for endogeneity using instrumental variables (4.5).

4.1 Energy Intensity and Local Financial Development (LFD): Benchmark regressions

We now turn to the econometric estimation of our core model (4), using energy intensity as dependent variable. Table V reports the results. The first column presents estimation of our baseline specification, controlling for basic firm characteristics and including country and 2-digit industry dummies to take into account for cross-country and cross-industry heterogeneity in our sample. Control variables included in the estimations but not reported in the table concern firm age, share of employees with degree as well as an indicator of firm performance, i.e. total sales growth over the last three years. The coefficient of interest α_{LFD} is the coefficient of the LFD variable. A negative coefficient implies that in more financially developed regions the firm-level energy intensity is lower, and this effect is statistically significant at 5 percent level. This first result confirms our testing assumption, the effect of local finacial market significantly influences firm's energy demand. The magnitude of the estimated coefficient is also economically significant. At the sample mean of energy intensity (0.09), an improving of the local financial development from the bottom quartile (the 25% of less financially developed regions) to the top quartile (the 25% of more financially developed regions), corresponding to an increase in LFD of 0.293, predicts a 14 percentage points decrease in energy intensity.[11] As expected, coefficients of capital and labour are positive and significant, implying that capital and labour increase the factor intensity of energy. Whereas the negative and 1 percent significant effect of output provides evidence of economies of scale in the use of energy.

A first concern is that in densely populated regions, one might expect to find higher concentration of bank branches, which could improve financial access of firms located in these areas. Therefore, even if the ease of financing is not limited to the number of branches available in a given region, our indicator may be potentially correlated with local population density. And, as shown in Morikawa (2012), firms' energy intensity may be negatively correlated to population density. In order to ensure that the effect of local financial development is not uniquely driven by a population effect, Column 2 considers the same specification inserting dummies for locality size. The coefficient of LFD is almost identical and remains significant at 5 percent level. Financial development

[11] The estimated effect is given by: 100*(-0.043*0.293)/0.09 = 14%, where 0.043 is the coefficient of the local financial development indicator in Table V column 1 and 0.293 is the interquartile range of this indicator; 0.09 is the sample mean of energy intensity, see Table A2.

Table V: Benchmark Regressions: Energy intensity and Local Financial Development

	Benchmark regressions					Macro controls	EU effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LFD	-0.043**	-0.042**	-0.042**	-0.056***	-0.048**	-0.040**	-0.042**	-0.043**
	(0.020)	(0.020)	(0.020)	(0.017)	(0.023)	(0.020)	(0.020)	(0.021)
Log output	-0.018***	-0.018***	-0.017***	-0.016***	-0.015***	-0.017***	-0.017***	-0.017***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Log capital	0.004*	0.003	0.003*	0.002	0.002	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log labour	0.017***	0.017***	0.015***	0.015***	0.012**	0.015***	0.015***	0.019***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
Private *de novo*			-0.017**	-0.019**	-0.017*	-0.015**	-0.017**	-0.017**
			(0.007)	(0.008)	(0.009)	(0.007)	(0.008)	(0.007)
Log GDP/capita						-0.055**		
						(0.026)		
Log energy use/$						0.298		
						(0.188)		
Inflation						-0.044*		
						(0.026)		
EU dummy							-0.085***	-0.091*
							(0.031)	(0.051)
LFD x (EU dummy)								-0.009
								(0.057)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Locality size controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
2-digit dummies	Yes	Yes	Yes	No	No	Yes	Yes	Yes
4-digit dummies	No	No	No	Yes	No	No	No	No
Country x 2-digit	No	No	No	No	Yes	No	No	No
Observations	1,263	1,263	1,261	1,260	1,261	1,165	1,261	1,261
R^2	0.155	0.163	0.168	0.294	0.303	0.175	0.168	0.168

The left-hand side variable is a measure of the firm-level demand for energy, expressed as the ratio of energy cost over total variable cost. "LFD" is our normalized measure of financial development by region, over the period 2002-2005 (cf. Section 4). Output is measured by the total sales, capital by the net book value of the capital and labour by the number of full-time employees. Private de novo, private subsidy of public company, joint-venture with foreign partner and other type of establishment are dummies capturing the way the firm was established (the last three dummy variables are included in the estimations but not reported in the table). The reference group is composed of former and actual state-owned companies. Per capita GDP is the per capita gross domestic product in the country in constant 2005 US dollars. Per dollar energy use is the energy used in the country in kg of oil equivalent per 1,000 dollars of GDP (constant 2005 PPP). Inflation is the annual consumer prices inflation, in percentage. EU dummy is a dummy equal to one for the (8) EU countries in the sample, and zero otherwise. "LFD x (EU dummy)" is the interaction between our variable of local financial development and the EU dummy. Firm controls are a set of variables capturing firm characteristics: age of the firm, share of employees with degree and the sales performance of the firm over the last three years (log of the ratio of total sales during the last fiscal year to sales three years ago). Locality size controls are a set of five dummies capturing the size of locality. 2-digit dummies and 4-digit dummies are industry dummies, disaggregated respectively at 2 and 4 digit. "Country x 2-digit" is a set of interactions between country dummies and 2-digit industry dummies. List of countries is provided in Appendix. Non-parametric robust bootstrapped standard errors (2000 replications) are reported in brackets in all the columns, except the forth and fifth. In column four and five, standard errors reported in brackets are robust and clustered by country-industry. *, **, *** indicate significance levels of 10, 5 and 1%, respectively.

still negatively affects firm-level energy intensity once we control for the size of population in the locality.

A large literature on transition economies underlines the positive impact of *de novo* private ownership on firm performance (Fisher, 2000). As for many other aspects, *de novo* companies should be more energy efficient compared to state and privatised enterprises. At the same time financial institutions may be more prone to grant *de novo* firms easier access to external finance. As Column 3 shows, private from start-up firms are significantly less energy intensive than other forms of establishment, particularly in comparison to formerly state owned firms. Although this effect is highly significant, it does not affect the financial access impact on energy intensity. The magnitude and the significance of LFD is unchanged compared to the previous regression implying low partial correlation between local financial development and firm establishment form. Specification of Column 3 represents our preferred benchmark specification.

Columns 4 and 5 show the basic results when changing the assumption for technology heterogeneity among firms. Column 4 replaces 2-digit industry dummies by 4-digit industry dummies. Whereas 4-digit industry dummies should be able to capture more precisely the technology differences in energy use across the same 2-digit sector, we cannot apply bootstrapping due to dataset limitation.[12] Despite the high number of additional explanatory variables, the coefficient of LFD is reinforced. Its magnitude is higher and it is now significant at 1 percent level, thus implying that local financial development is partially correlated with firms' specialisation in energy intensive sub-sectors. Some energy intensive industries benefit from a better access to financial markets than other sectors, partly compensating the overall negative impact of financial development on energy demand. Column 5 includes 2-digit industry dummies differentiated by country (interactions between 2-digit industry dummies and country dummies) in order to take into account for potential technology differences across firms in same sector but in different countries. As in previous regression this implies a large number of explanatory variables added to the basic estimation which limits the use of bootstrapping. Coefficient of LFD is significant and slightly more negative than in Column 3 implying that in some countries access to financial market is easier for energy intensive sectors.

In Column 6 we introduce three macroeconomic controls. Hence, we include in our regression GDP per capita – as proxy for country development level – inflation and country-level energy intensity. While its overcontrolling, we want to ensure that our indicator is not affected by nationwide heterogeneity not captured by country dummies. We find the expected effects of macroeconomic variables. Manufacturing sector in more developed countries consume significantly less energy to produce. The negative sign of the coefficient of inflation suggests that energy prices increase relatively more than other costs. Country

[12] We include 4-digit industry dummies when it is computationally possible and when there is no need for bootstrapping.

energy intensity is not significant because its effect is well captured by country dummies. Introduction of these controls only marginally impacts the coefficient of LFD, which remains almost unchanged compared to Column 3.

Finally, one potential objection is that the estimated effect is driven by EU *vs.* non-EU difference, even if part of the difference should be the contrast in financial markets. EU countries should have more financially developped markets, potentially less segmented and more efficient, and hence potentially more able to provide financial supply to cost-effective energy saving investments. In Column 7 we introduce an EU dummy in our regression. The EU new members (since 2004 and until 2007) are on average significantly less energy intensive compared to non-EU members, but the effect of LFD remains very stable compared to previous regressions. To test the assumption that the LFD effect is affecting differently firms' energy intensity in EU compared to non-EU zone, we introduce in column 8 the interaction between our LFD indicator and the EU dummy. However, the coefficient of the interaction term is not significantly different from zero. Results of Column 8 do not support any significant diffrence between EU and non-EU countries in the impact of LFD on energy intensity.

Overall, results of Table 5 support our assumption of a negative impact of financial development on firm-level energy consumption. Limited access to supply of financial funds seems to limit firm's ability to undertake energy saving investments, and thus provides an explanation of the maintaining of highly elevated levels of energy consummed in the ECA region. Nevertheless, if *local* financial development matters, than its impact should be lower for firms in less need of external funds. As shown in the literature,[13] the effect of local financial development should be non-linear, smaller firms being more affected by local financial conditions. We try to test this proposition in the subsequent subsection.

4.2 Does Firm Size Matter?

As pointed out by previous literature, firms should not be equally affected by financial access at the local-level. Smaller firms should be more heavily dependent of available sources of finance in their region than larger firms. Several intuitive and theoretical arguments may explain this. First, larger firms have higher internal capacities to draw funds from a broad geographical area. Then, imperfect information and the relied transaction costs should be lower for banks when dealing with large companies (Petersen and Rajan, 2002). Reliable information may be of easier access and less costly (available balance sheets, independent audit, etc.). Moral hazard should be lower because of potential prior relationships (Berger et al., 2005). Finally, due to economies of scale banking transaction costs should decrease proportionately to the borrowed amount. So, lending cost should be lower for larger firms (Fafchamps and Schündeln, 2013).

[13] See Fafchamps and Schündeln (2013) for a discussion of this topic.

Table VI: The Differential Effect of Local Financial Development: Does firm size matter?

	Less than 47 employees	More than 46 employees	Non-linear Effect	Country Fin. Dev. *vs.* Local Fin. Dvt.		Non-linear Effects
	(1)	(2)	(3)	(4)	(5)	(6)
LFD	-0.064***	-0.029	-0.116***		-0.056***	-0.130***
	(0.024)	(0.028)	(0.043)		(0.016)	(0.050)
LFD x (log labour)			0.018*			0.022*
			(0.011)			(0.012)
Private credit/GDP				-0.003***	-0.002*	-0.001
				(0.001)	(0.001)	(0.001)
Private credit/GDP x (log labour)						-0.000**
						(0.000)
Log output	-0.024***	-0.009*	-0.017***	-0.013***	-0.017***	-0.017***
	(0.004)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
Log capital	0.003	0.004	0.003	0.004**	0.001	0.003
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Log labour	0.023***	0.014	0.006	0.008*	0.015***	0.015**
	(0.007)	(0.009)	(0.007)	(0.005)	(0.004)	(0.007)
Private *de novo*	-0.010	-0.023**	-0.017**	-0.010	-0.017***	-0.015**
	(0.013)	(0.011)	(0.008)	(0.007)	(0.007)	(0.007)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Locality size controls	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
2-digit dummies	Yes	Yes	Yes	No	No	Yes
4-digit dummies	No	No	No	Yes	Yes	No
Observations	618	643	1,261	2,121	1,164	1,165
R^2	0.216	0.210	0.171	0.213	0.310	0.181

The left-hand side variable is a measure of the firm-level demand for energy, expressed as the ratio of energy cost over total variable cost. Following the BEEPS (2009) definition, small and medium firms have less than 100 employees and large firms more than 99 employees. "LFD" is our normalized measure of financial development by region, over the period 2002-2005 (cf. Section 4). "LFD*log labour" is an interaction term between the local financial development variable and a proxy for the firm size, i.e. log of the number of employees. Private credit/GDP is domestic credit to private sector as percent of GDP and "Private credit x (log labour)" is an interaction term between private credit/GDP and log of the number of employees. Output is measured by the total sales, capital by the net book value of the capital and labour by the number of full-time employees. Private de novo, private subsidy of public company, joint-venture with foreign partner and other type of establishment are dummies capturing the way the firm was established (the last three dummy variables are included in the estimations but not reported in the table). The reference group is composed of former and actual state-owned companies. Firm controls are a set of variables capturing firm characteristics: age of the firm, share of employees with degree and the sales performance of the firm over the last three years (log of the ratio of total sales during the last fiscal year to sales three years ago). Locality size controls are a set of five dummies capturing the size of locality.2-digit dummies and 4-digit dummies are industry dummies, disaggregated respectively at 2 and 4 digit. Robust standard errors clustered by country-industry are reported in brackets in columns 1, 2 and 4. In columns 3, 5 and 6 are reported, in brackets, non-parametric robust bootstrapped standard errors (2000 replications). *, **, *** indicate significance levels of 10, 5 and 1%, respectively.

In Table VI, we keep our benchmark regression (from the Table V, Column 3) and we check whether the effect of local financial development is stronger for smaller firms. For this purpose we split our sample according to the firm size. If local financial conditions matter, than they should mostly affect smaller firms. In order to keep the same statistical power we divide our sample into two equal subsamples (Columns 1 and 2).[14] Column 1 displays the estimation results for firms with less than 47 employees. The coefficient of LFD is negative and strongly significant (at 1 percent level). By comparison, in Column 2 the sample is composed of half of the sample with larger companies (*i.e.* with more than 46 employees). For larger firms, the effect of local financial development is not significant, thus confirming our assumption that energy consumption of smaller enterprises is more strongly impacted by local finacial conditions.

To directly test the U-shaped relationship between the effect of local financial conditions on energy intensity and firm size, we introduce in our benchmark regression an interaction between firm size and our LFD variable (Column 3). A positive coefficient of the interaction variable will thus corroborate that smaller firms benefit proportionnately more from local sources of finance to improve their energy efficiency. Results support previous findings. The impact of LFD on firm demand for energy is strictly negative and highly significant for smaller firms, but the effect is that much less important as firm size increases. For small firms, local access to external finance is crucial for energy savings.

The interaction term also allows to quantify, according to the firm size, when the impact of local financial development has no more a statistically negative influence on firm energy intensity. The effect of LFD on firms' energy demand, given by - 0.116 + 0.018*(log labour), is strictly negative for firms with less than 629 employees.[15] This represents a major share of firms included in our data (around 95%). Coefficients of the first three columns of Table VI have the expected effects. As might be anticipated, only very large firms seem to not be constrained by local financial supply conditions to finance their cost-effective energy efficient investments.

4.3 Local Financial Development *vs.* Country Financial Development

So far, we have shown that an increased access to local finance is a key factor to enhance energy performances of firms, especially when firms are of smaller size. Since our data cover several countries, it is important to ascertain that our *local* financial development effect on energy intensity is not simply reflecting *country* differences in financial depth. Furthermore, we can directly compare effects of

[14] Results are not significantly affected if subsamples are constructed using the BEEPS methodology for firm size (less than 100 employees for small and medium enterprises).

[15] The number of employees is given by $e^{0.116/0.018} = 629$.

nationwide financial access agaist local financial development. Indeed, large firms should be more able to take advantage of countrywide financing opportunities than do smaller businesses. The cross-country nature of our sample allows to assess, for different firm sizes, what is the more appropriate scope of financial market (local-level *vs.* country-level) to improve firms' energy efficiency.

Column 4 of Table VI, reestimates our benchmark regression including a rather standard proxy for country level financial development, *i.e.* domestic credit provided to private sector (as percent of GDP). This brings further evidence about the effect of financial development on firm-level energy intensity. An increase of the variable Private credit/GDP significantly decreases firm-level energy intensity. Moreover, as regressions include country fixed effects, we can state that the financial development effect on energy consumption is not driven by the construction of our LFD indicator.

In Column 5, we include in the regression both indicators of financial development at the country as well as at the local levels. Whereas the significance and the magnitude of the Private credit/GDP coefficient decreases in both columns, the coefficient of LFD remains very similar to Column 3 of Table V (our benchmark regression). LFD effect on energy intensity is still negative and dominates the country financial development effect. This supports the idea that our estimated effect of local financial development on energy intensity does not simply reflect cross-country differences in financial depth.[16]

Finally, the last column of Table VI shows that an improvement of credit supply at the national level affects small firms mainly through local financial markets. Indeed, the variable of country financial development alone is statistically not significant, whereas the coefficient of LFD is negative and significant at 1 percent level. The LFD indicator interacted with the number of employees is still positive, indicating a decreasing magnitude of the effect of local financial development with firm size (as in Column 3). By contrast, an interesting result concerns the negative sign of the interaction between country level financial development and firm size (Private credit/GDP x (log labour)). The effect of countrywide credit market depth decreases that much more energy intensity as firm size increases.[17] This seems to suggest that larger firms are more able to seize broader financing opportunities to finance energy efficiency investments.

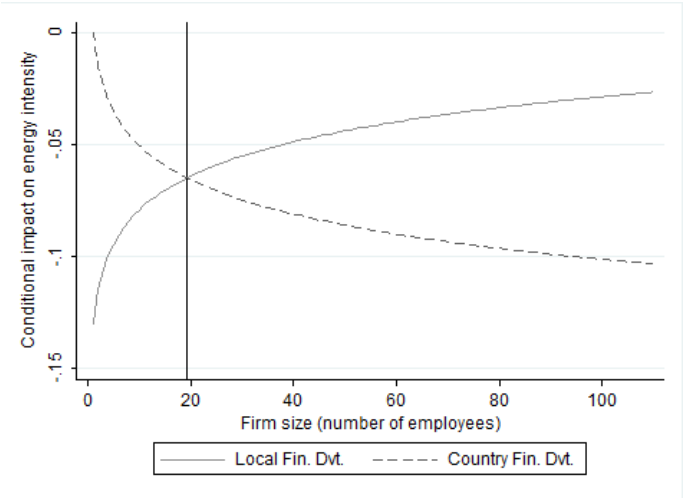
Although our regional splitting do not provide a breakdown of equivalent geographical size in each country, the data seem to confirm that for small firms local access to external finance is crucial for energy saving. Results of Column 6

[16] It should be noticed that the correlation between our local financial development indicator and Private credit/GDP variable is around 0.3, implying that our variable of local financial development is more about regional ease of credit access than it is about the absolute quantity of credit supplied in the region.

[17] Changing our variable of country financial development, using the bank credit over GDP, maintain almost unchanged results for the LFD variable comparing to Table VI.

make possible the comparison between effects of *local* financial development and *country* financial development. By normalizing the variable Private credit/GDP as we did for our indicator of local financial development (see Section 3, equation (6)), we can directly assess at what firm size the effect of country financial market deepness surpasses the impact of local financial market.[18] Figure II provides the marginal impact on energy intensity of both local and country (normalized) financial development indicators, conditional to firm-level number of employees. From this figure we can see that the effect of country financial development outreach the effect of LFD when firm size exceeds the threshold of twenty employees. Our data seems to indicate that improvements of local financial conditions have a greater effect on small firms' energy consumption, whereas nation-wide credit supply expansion (as expressed by the level of Private credit/GDP) has higher influence on medium and large firms' energy demand.

Figure 2: Firm size conditional effect of local *vs.* country financial markets



The conditional effect of Local Financial Development is obtained by: $-0.13 + 0.022 * log(numberofemployees)$. The conditional effect of Country Financial Development is obtained by: $-0.022 * log(numberofemployees)$.

From an economic policy point of view this is an interesting and unexplored finding. Our estimation suggests that an active financial policy to improve small firms' energy performances is more effective when channeled through local

[18] We normalize the country financial development as follows:

$$\frac{PrivateCredit/GDP_j}{max(PrivateCredit/GDP_j)} \tag{7}$$

Where j denotes for country. Replacing this rescaled variable of Private Credit/GDP in the regression of Table VI, Column 6, provides a coefficient of -0.022 for the "Private Credit/GDP x (log labour)" variable.

financial structures. Whereas energy efficiency improvements of larger firms (from twenty employees and more) may be higher with an overall deepness of credit supply at the country-level. These results also seem to indicate that an overall enhancement of the financial market functionning, in particular by limiting geographical segmentation of the market, should have a positive impact on firms' energy saving investments.

4.4 Energy intensity and Local Financial Development: Alternative Specifications

In order to check for the robustness of our results, in Table VII we change our benchmark specification, using alternative specifications and different proxies for our endogenous variable. First, we carry out our benchmark regression again, but without capital and/or labour (Columns 1 and 2) to follow the basic specification of Bloom et al. (2010). We run these estimations including 4-digit level industry dummies, to be more able to take into account for capital and labour heterogeneity across firms. Results remain significant and close in magnitude to our benchmark regressions. In Column 3 we present energy share in logarithm. For all the regressions we find a significant and negative impact of LFD on the various energy dependent variables.

In column 4, the dependent variable is the ratio of energy expenditure over gross output (measured by total sales) including the independent variables of our benchmark regressions (Table V). Some recent papers, as Bloom et al. (2010) or Morikawa (2012), use as proxy for energy intensity the share of energy expenses over total revenues. This specification is relevant under perfect competition, since total cost will be equal to total sales. If this assumption does not hold total revenue will be equal to marginal cost plus a markup. Under imperfect competition, changes in energy share over total sales may also be driven by changes in market power. Still, results in Column 4 support findings from our benchmark regressions. The magnitude of the estimated coefficient is somewhat lower with this alternative specification, indicating partial correlation between our variable of local financial development and firm's markup. This result is in line with Guiso et al. (2004) who show that local financial development increase competition among firms, thus reducing market power. All other things equal, the decrease in markup decreases the denominator and increases the energy share over total revenue. This specification may partially hide the overall effect of financial development on energy intensity.

Finally in Column 5, we present our results for a different source of energy (fuel). One of the major issue related to energy consumption, is its environmental impact, in particular through air pollutant emissions of fossil fuel combustion (Cole et al, 2008). To test whether local financial development may influence firm-level environmental performances we use fossil fuel intensity as dependent

Table VII: Local Financial Development and Energy Intensity: Alternative specifications

	Energy share	Energy share	Log energy share	EE/GO	Fuel share
	(1)	(2)	(3)	(4)	(5)
LFD	-0.041**	-0.057***	-0.559***	-0.025*	-0.025*
	(0.047)	(0.016)	(0.204)	(0.015)	(0.014)
Log output	-0.007***	-0.008***	-0.306***	-0.030***	-0.006***
	(0.003)	(0.003)	(0.037)	(0.006)	(0.002)
Log capital		0.003*	0.073***	0.004*	0.002*
		(0.002)	(0.024)	(0.002)	(0.001)
Log labour			0.201***	0.028***	0.004
			(0.052)	(0.006)	(0.003)
Private *de novo*	-0.025***	-0.023***	-0.266***	-0.012	-0.002
	(0.006)	(0.008)	(0.096)	(0.008)	(0.005)
Firm controls	Yes	Yes	Yes	Yes	Yes
Locality size controls	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes
2-digit dummies	No	No	Yes	No	Yes
4-digit dummies	Yes	Yes	No	Yes	No
Observations	1,553	1,262	1,244	1,312	1,261
R^2	0.240	0.286	0.172	0.267	0.129

The dependent variable in the first two columns is the ratio of energy expenditure over total variable cost. Log energy share is the log of the ratio of energy cost over total variable cost. EE/GO is the ratio of energy expenditure over gross output (measured by total sales). Fuel share is the ratio of fuel cost over total variable cost. "LFD - Local Financial Development" is our normalized measure of financial development by region, over the period 2002-2005 (cf. Section 4). Output is measured by the total sales, capital by the net book value of the capital and labour by the number of full-time employees. Private de novo, private subsidy of public company, joint-venture with foreign partner and other type of establishment are dummies capturing the way the firm was established (the last three dummy variables are included in the estimations but not reported in the table). The reference group is composed of former and actual state-owned companies. Firm controls are a set of variables capturing firm characteristics: age of the firm, share of employees with degree and the sales performance of the firm over the last three years (log of the ratio of total sales during the last fiscal year to sales three years ago). Locality size controls are a set of five dummies capturing the size of locality. 2-digit dummies and 4-digit dummies are industry dummies, disaggregated respectively at 2 and 4 digit. Non-parametric bootstrapped standard errors (2000 replications) are reported in brackets in columns three and five. In the rest of columns, standard errors reported in brackets are robust and clustered by country-industry. *, **, *** indicate significance levels of 10, 5 and 1%, respectively.

variable. The coefficient of LFD is negative and significant, but somewhat lower than previously.

Table VII results suggest that the impact of the LFD do not depend on the definition of our energy dependent variable neither on the specification of the translog function. For all the regressions we find a significant and negative impact of LFD on the energy dependent variables.

4.5 Energy Intensity and Local Financial Development: Dealing with endogeneity

We construct our LFD variable using different firm's answers (compared to the benchmark regression in Table V) and previous survey's years (see Section 3 of the paper). Even though, we may have some endogeneity problems either due to omitted variables or reverse causality. In Table VIII we try to adress both endogeneity problems.

We first use the methodology proposed by Rajan and Zingales (1998) and used by Guiso et al. (2004) for possible regional omitted variables. As a matter of fact the LFD variable is constructed on the regional level and our results may be due to other local factors apart from the financial development. If we assume that some firms may less benefit from the local financial development we can control for local characteristics and see if it is still the case. As we expect large firm to be less constrained by local finance, we control for the interaction between firm size and LFD — this should have a positive impact on energy intensity. In other words the negative effect of the LFD on energy intensity is less and less negative when the firm get larger. When we control for omitted regional characteristics in Columns 1, 2 and 3, we still have the expected positive effect of our interaction variable. Results are similar to Table VI, and using firms' gross output as measure of firm size (Column 2) does not affect significantly previous findings.

Concerning the reverse causality issue, we use instrumental variables (in Columns 4, 5 and 6) to check if enterprises looking for energy savings financing are not generating the local finance development. Banks may also choose their location according to the energy efficiency of local firms. In order to check if our LFD effect of energy consumption is not reverse we instrument our variable with exogenous determinants of LFD. We use the number of banks over population density and the interest rate spread at the country-level. Both variables should capture a countrywide competition in the banking sector. We choose those variables because it is difficult to assume that firm energy consumption can affect the spread or the number of banks for the whole country - furthermore for the previous period (2002-2005). The spread had already been used, as an IV, by Beck et al. (2005). We expect increased competition in the banking sector to

Table VIII: Local Financial Development and Energy Intensity: Dealing with omitted variables and reverse causality

	Regional fixed effects: interacting LFD and firm size			IVs: number of banks/pop. density, interest rate spread		
	(1)	(2)	(3)	(4)	(5)	(6)
LFD				-0.070***	-0.075***	-0.079***
				(0.022)	(0.020)	(0.021)
LFD x (log labour)	0.018*		0.023**			
	(0.010)		(0.011)			
LFD x (log output)		0.016*				
		(0.008)				
Private credit/GDP			-0.000			
			(0.001)			
Private credit/GDP x (log labour)			-0.000*			
			(0.000)			
Log output	-0.017***	-0.025***	-0.017***	-0.012***	-0.011***	-0.010***
	(0.003)	(0.005)	(0.003)	(0.002)	(0.002)	(0.002)
Log capital	0.002	0.002	0.001	0.005***	0.005**	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log labour	0.006	0.015***	0.015**	0.006*	0.006*	0.006
	(0.007)	(0.004)	(0.007)	(0.004)	(0.004)	(0.003)
Private *de novo*	-0.019**	-0.018**	-0.017**	-0.019***	-0.019***	-0.021***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Locality size controls	Yes	Yes	Yes	No	Yes	Yes
2-digit dummies	Yes	Yes	Yes	Yes	Yes	No
4-digit dummies	No	No	No	No	No	Yes
Region fixed effects	Yes	Yes	Yes	No	No	No
Observations	1,261	1,261	1,165	1,103	1,103	1,103
R^2	0.219	0.219	0.238			
F test of excluded instruments				98.13***	108.80***	90.07***
Sargan-Hansen stat (p-value)				0.190	0.727	0.365

The left-hand side variable is a measure of the firm-level demand for energy, expressed as the ratio of energy cost over total variable cost. "LFD - Local Financial Development" is our normalized measure of financial development by region, over the period 2002-2005 (cf. Section 4), instrumented by country related variables. The IV uses as instruments the country number of banks divided by population density and the lending rate minus the deposit rate in percentage (interest rate spread). Both variables are averaged between 2002 and 2005. "LFD x (log labour)" is an interaction term between the local financial development variable and a proxy for the firm size, i.e. log of the number of employees. "LFD x (log output)" is an interaction term between the local financial development variable and an alternative proxy for the firm size, i.e. log of output. Private credit/GDP is domestic credit to private sector as percent of GDP and "Private credit x (log labour)" is an interaction term between private credit/GDP and log of the number of employees. Output is measured by the total sales, capital by the net book value of the capital and labour by the number of full-time employees. Private de novo, private subsidy of public company, joint-venture with foreign partner and other type of establishment are dummies capturing the way the firm was established (the last three dummy variables are included in the estimations but not reported in the table). The reference group is composed of former and actual state-owned companies. Firm controls are a set of variables capturing firm characteristics: age of the firm, share of employees with degree and the sales performance of the firm over the last three years (log of the ratio of total sales during the last fiscal year to sales three years ago). Locality size controls are a set of five dummies capturing the size of locality. 2-digit dummies are industry dummies disaggregated at 2 digit. Robust standard errors clustered by country-industry are reported in brackets in all the columns. *, **, *** indicate significance levels of 10, 5 and 1%, respectively.

improve financial supply at the local level, and influence energy intensity only through its effect on local financial conditions. Results of the usual tests for instrumental variable aprroach strongly support these assumptions. Overall, the negative impact of LFD on energy consumption remains very stable and significant.

5 Conclusions

Energy consumption is an ongoing issue for the long-term sustainability of an economic system. Manufacturing sector is responsible of one third of the world wide consumed energy and almost one half of the energy consumed in the ECA region. Moreover, energy efficiency related literature emphasizes the existence of a "gap" between the optimal level of energy-efficient investments and the current level of such investments. One of the suggested reasons concerns the availability of financial funds to make energy-saving investments.

Countries of Europe and Central Asia, among the world's leaders of energy intensity, offers fertile ground for improve energy efficiency. Regarding the overall modernizing margins of their manufacturing sector, financial constraints should be of a great importance for firms operating in this region.

Therefore, our study focus on the financial access explanation of manufacturing firm-level energy intensity in twenty-wo post-communist countries in Europe and Central Asia. Our findings support our main testing assumption that is financial access development is robustly associated with decreasing energy intensity.

We examine more specifically whether *local* financial market development affects energy intensity. Results display two main findings. The first is that local financial development is significantly associated with lower energy use of firms operating in the region. This effect is not simply reflecting difference in financial development between EU and non-EU members. At the sample mean of energy intensity, an improvement of the LFD from the 25th percentile to the 75th percentile of the distribution is associated with a 14% potential reduction of firms' energy intensity. The second, the effect of local financial conditions is stronger for small and medium size firms. Our results show that the effect of our LFD indicator is strictly negative for firms with less than 630 employees. Additionally, we decompose the effect of financial access on energy intensity conditional to firm size. Our results investigate the connection between the firm size conditional effect of finance on energy intensity and the scope of the financial market. Larger firms are able to improve their energy consumption through broader (nationwide) financial conditions. Whereas smaller enterprises are more constrained by local financial access, and benefit relatively less from country financial in-depth.

Our empirical findings suggest that the *local* financial development effect on energy intensity is larger than the effect of countrywide financial conditions only for smaller firms, up to twenty employees. Whereas, both variables (LFD and country financial development) are partially correlated and should both catch an overall "financial access" effect, this finding is important from an economic policy point of view. An effective and appropriate policy aiming to decrease firms' energy consumption through a better access to financial funds, should focus local implementation and targeting small businesses.

In a broader perspective, our results imply further policy recommendations. Thus, improving information on medium term profitability of energy-saving investments should also increase incentives to invest in energy efficiency. Deepening the competition among banking sector and avoid market segmentation, should improve financial access at the local level. Finally, it is important to reinforce and/or implement bankruptcy law and appropriate legal framework for financial sector (Rona-Tas and Guseva, 2013) in ECA region. By ensure loans pay-back, this should improve the overall conditions of financial availability, in particular for small sized borrowers.

A Appendix

Table A1: List of countries

Transition:
Albania[a], Azerbaijan[a], Belarus[a], Bulgaria[a], Croatia[a], Czech Republic[a,b], Estonia[a,b], Georgia[a], Hungary[a,b], Kazakhstan[a], Kyrgyz Republic, Latvia[a,b], Lithuania[a,b], Macedonia FYR[a], Moldova[a], Poland[a,b], Romania[a], Russian Federation[a], Serbia[a], Slovak Republic[a,b], Slovenia[a,b], Tajikistan, Turkmenistan, Ukraine[a], Uzbekistan[a]
Industrialised:
Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Malta, the Netherlands, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, UK, USA
Emerging:
Argentina, Brazil, Chile, China, Colombia, India, Indonesia, Jordan, Malaysia, Mexico, Hong Kong, Morocco, Pakistan, Peru, Philippines, South Africa, South Korea, Thailand, Turkey, Venezuela

[a]Sampled countries included in the final sample in tables 3 to 8.
[b]European Union members of the ECA region as in 2004.

Table A2: Summary statistics - Firm-level sample BEEPS 2008-2009

	Mean	Std. Dev.	Minimum	Maximum	N
Energy intensity	0.09	0.105	0	0.734	1263
Log output	16.785	2.876	8.825	26.427	1263
Log capital	15.442	2.995	7.09	27.048	1263
Log labour	3.917	1.42	0.693	8.532	1263
Firm age	19.366	21.038	1	183	1263
Share of skilled workers	21.538	21.66	0	100	1263
Growth	0.536	1.114	-6.026	7.412	1263
Firm establishment:					
Former state owned	0.282	0.45	0	1	1261
State owned	0.016	0.125	0	1	1261
Private *de novo*	0.636	0.481	0	1	1261
Private subsidy of public company	0.016	0.125	0	1	1261
Joint venture with foreign partner	0.04	0.195	0	1	1261
Other type of establishment	0.012	0.108	0	1	1261
Locality population:					
Capital city	0.263	0.44	0	1	1263
Over 1 million	0.095	0.293	0	1	1263
Over 250,000 to 1 million	0.147	0.355	0	1	1263
Over 50,000 to 250,000	0.209	0.406	0	1	1263
Less than 50,000	0.286	0.452	0	1	1263

Table reports summary statistics of the variables used in our regressions and based on the BEEPS (2008-2009) data. Energy intensity is expressed as the ratio of energy cost over total variable cost. Output is measured by the total sales, capital by the net book value of the capital and labour by the number of full-time employees. Firm age, share of skilled workers and growth represent our firm controls: age of the firm, share of employees with degree and the sales performance of the firm over the last three years (log of the ratio of total sales during the last fiscal year to sales three years ago). Former state owned, state-owned, private de novo, private subsidy of public company, joint-venture with foreign partner and other type of establishment are dummies capturing the way the firm was established. Locality population are a set of five dummies capturing the size of locality.

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