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Do Natural Resource Sectors Rely Less on External Finance than Manufacturing Sectors?

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Abstract: The finding that industrial sectors differ in their dependence on external finance for sector-specific technological reasons and, thus, rely to a different degree on financial development has become a major concept in studies conducted on both growth and trade. Although natural resources might play an important role in each of these fields, research on industries' financial dependence has been limited so far to manufacturing. By focusing on the natural resource sectors, the present paper aims to close this gap in its analysis. It rejects the common view that the natural resource industry in particular is less dependent on the financial system, and finds that the results of the analysis depend on the specific measure being applied. Measures relating investment and cash flow indicate high external dependence, while measures accounting for more short-term liquidity needs demonstrate rather low external dependence of natural resource firms. These results do not change considerably over time or across countries.

JEL classifications: G20, G30, O13, O14, O16

Keywords: Financial development, external dependence, natural resources

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1 Introduction

The seminal work by Rajan and Zingales (henceforth: RZ, 1998) finds that industries differ systematically in their need for external financing provided by the financial sector. That is, some industries rely more heavily on the financial system than others. The communication-equipment sector, for example, is known to be rather dependent on external finance since it has a limited ability to finance its investment needs through its own funds. Hence, different industries benefit to varying degrees from the level of a country's financial development. Rajan and Zingales assume that the ranking of sectors according to their level of financial dependence is relatively stable over time and across countries.

This observation has served as a key element in a vast literature combining finance with growth and trade issues. For instance, a country that is financially highly developed is considered to have a comparative advantage in financially dependent sectors. This, in turn, has consequences for sectoral growth and the country's trade pattern.[2]

So far, the analysis of financial dependence has been limited to manufacturing sectors.[3] In some cases, however, it is worthwhile to also include natural resource sectors such as oil, gas or mining. Cross-sectoral financial heterogeneity could play an important role in resource-oriented economies. The aim of this paper is to compare the financial dependence of natural resource sectors with that of manufacturing. It is the first in a series of papers that seek to investigate the interaction of natural resources with finance and trade.

It is often supposed that natural resource firms, especially oil and gas companies, do not require as much external financing as other industries (Guriev, Plekhanov and Sonin 2009, p.15). In contrast, this paper presents a rather mixed picture, arguing that the degree to which resource sectors rely on the financial infrastructure depends on the type of measure that is being used. In particular, measures relating investment and cash flow show high external dependence, while measures that account for more short-term liquidity needs indicate that the resource sectors are characterized by a rather low level of external dependence. The paper further supports the view that these results do not change much over time or across countries.

[2]See among others Rajan and Zingales (1998), Beck (2002), Beck, Demirgüç-Kunt and Levine (2004) and Svaleryd and Vlachos (2005).

[3]Calculations of manufacturing sectors' external dependence have been made, for example, by Rajan and Zingales (1998), Kroszner, Laeven and Klingebiel (2007) and Eichengreen, Gullapalli and Panizza (2011).

The paper is structured as follows: Section 2 briefly defines what is meant by natural resources. Section 3 presents the different measures of financial dependence and how they are calculated. In Section 4, the empirical results are presented. Section 5 examines whether the two crucial assumptions regarding stability over time and across countries hold. This is then followed by the conclusion in Section 6.

2 Natural Resources

For the purposes of this analysis, natural resources generally constitute "stocks of materials that exist in the natural environment that are both scarce and economically useful" (World Trade Report 2010, p.5). Such materials are either used in a raw state or after a minimal amount of processing. Most natural resources are exhaustible in cases of mismanagement, including renewable resources such as fish or forests. This paper will focus on non-renewable resources, like fossil fuels and metallic ores, because of the greater availability of data. The forestry and fishing sector, by contrast, allow comparatively few observations to be made. Agricultural sectors are generally excluded from the analysis. A main characteristic of non-renewable natural resources is their extremely uneven distribution among countries. Most are so-called point resources with high concentrations in certain regions of the world. This leads to over-specialization in some countries, which, for example, are abundantly endowed with oil or minerals (World Trade Report 2010, p.51). For these countries, an assessment of the natural resource sectors' role in the national economy is of particular importance.

3 Measures of Financial Dependence

In the following, different approaches will be presented for measuring the degree of a firm's financial dependence. This includes the methodology applied by Rajan and Zingales (1998), which relates capital expenditures to operative cash flow. Here, I will vary the exact composition of cash flow. Alternative measures proposed in the finance literature include research and development (R&D) expenses, the ratio of inventories to sales and the ratio of short-term debt to sales.

3.1 General Assumptions

All measures seek to identify a company's need for external finance, which is also to say liquidity. Since there is no available data on the *actual* continuous amount of liquid funds a firm uses to finance its operations, the measures are considered to be proxies. Thus, they generally constitute a compromise between economic logic and data availability.

A firm that cannot finance its investment with internal cash flow needs to find external investors. This need for external financing is believed to be systematically different across industries. According to Rajan and Zingales (1998), the concept of financial dependence relies on two assumptions.

First, the differences between industries are assumed to be relatively stable over time because of persistent technological factors, such as those relating to project scale, the gestation and cash harvest period, as well as the need for continual investment (Rajan and Zingales 1998, p.563). Von Furstenberg and von Kalckreuth (2006, p.543) further identify these rather vague characteristics of structural determinants. They include properties of the production function, like the specification of human capital, the level of technological progress, scale effects and factor intensity, as well as characteristics of input use such as the depreciation rate, materials intensity and the degree of dependence on external inputs. Other relevant features might be an industry's general degree of risk as well as the leverage and collateralization potential.[4] These characteristics are not specific to an individual firm, but are typical of the industry as a whole. Accordingly, the sectors' ranking of external dependence is expected to be stable over time.

Moreover, the technological argument leads to the assumption that the sectors' ranking of external dependence is similar across countries. Differences between industries are said to be more significant than differences across countries. In a sense, this rules out the possibility of "factor intensity reversals": the mining sector in the United States, for example, is as financially intensive as the one in Australia and elsewhere. The analysis, therefore, can be limited to U.S. data, which - in addition to data availability and simplifying the approach - brings with it some further advantages. Due to strict disclosure requirements, using financial data from publicly listed U.S. firms, although

[4]This paper does not explicitly examine the relation between these particular characteristics and firms' financial dependence. This has been done, for example, by von Furstenberg and von Kalckreuth (2006) who find a rather weak correlation.

not fully representative of *all* U.S. firms, ensures that the data is comprehensive. Moreover, it is reasonable to assume that in the highly developed U.S. financial market, the behavior of these companies captures their optimal asset structure and, thus, their unbiased demand for external financing (Manova 2009, p.9). Hence, a relatively pure proxy of liquidity needs can be demonstrated where the reported amount of the firms' external financing is equal to the desired amount.[5]
Whether these two assumptions hold is tested in this paper.

3.2 Calculation of Measures

(1) The original external dependence measure by Rajan and Zingales (1998) captures the share "of desired investment that cannot be financed through internal cash flows generated by the same business" (p.564). It is calculated as capital expenditures minus operative cash flow divided by capital expenditures. Capital expenditures are gross investment in fixed capital (von Furstenberg and Kalckreuth 2006, p.546). Acquisitions are excluded in order to obtain a ratio which mainly refers to the production process of a firm capturing more sound technological characteristics. The values for sectors' financial dependence in the 1980s (except natural resources) taken from the original paper by Rajan and Zingales (1998) serve as a benchmark for the following variations[6].

(2) Using the same financial database as Rajan and Zingales (1998), specifically, Standard & Poor's Compustat North America, I aim to reproduce their results. In Compustat, the mnemonic for capital expenditures is $CAPX$. The composition of cash flow is more complicated, however. Adhering as closely as possible to Rajan and Zingales (1998), I use total funds from operations ($FOPT$) plus decreases in inventories ($INVT$) and receivables ($RECT$) plus increases in payables (AP).[7] This is basically in line with standard calculation of cash flow in the finance literature where outstanding payables increase a firm's liquidity, while increasing inventories and receivables diminish it. Since the year-on-year changes of these positions are not available as own

[5]Using the U.S. sectors' external dependence as a concept in growth and trade literature, the data can easily be extrapolated to other countries, thereby avoiding the problem that the firms' financial dependence is endogenous to the country's specific financial development (Kroszner, Laeven and Klingebiel, 2007).

[6]For some 3-digit sectors, values are taken from Kroszner, Laeven and Klingebiel (2007) because Rajan and Zingales (1998) sometimes use a more disaggregate sector classification.

[7]Rajan and Zingales (1998) do not indicate which exact Compustat variable (mnemonic) they take for inventories, receivables and payables.

variables in the 1980s, the changes of year-on-year absolute levels are calculated. The formula for a firm in year t is $(CAPX_t - [FOPT_t - (INVT_t - INVT_{t-1}) - (RECT_t - RECT_{t-1}) + (AP_t - AP_{t-1})])/CAPX_t$ where $INVT$, $RECT$ and AP refer to the stocks at the end of the period. I call this measure RZ modification no. 1.

(3) For periods after 1990, it is necessary to modify the above calculation of the operative cash flow.[8] Again following Rajan and Zingales (1998), total funds from operations $FOPT$ are calculated as the sum of income before extra items IBC, depreciation DPC, deferred taxes $TXDC$, equity in net loss $ESUBC$, sale of fixed assets and investments loss $SPPIV$ and funds from other operations $FOPO$. Decreases in inventories and receivables as well as increases in payables now have own Compustat mnemonics. The formula for this RZ modification no. 2 is: $(CAPX_t - [IBC_t + DPC_t + TXDC_t + ESUBC_t + SPPIV_t + FOPO_t + INVCH_t + RECCH_t + APALCH_t])/CAPX_t$.

(4) A Compustat variable that is very close to the cash flow I calculated for the previous measure is the net cash flow from operative activities $OANCF$. This aggregate figure has also been available since the early 1990s, but is reported by a larger number of U.S. companies and, therefore, leads to a dataset with more observations. The calculation for this RZ modification no. 3 contains only two items: $(CAPX_t - OANCF_t)/CAPX_t$. The RZ modifications no. 2 and no. 3 will prove to deliver very similar results.

(5) In addition to the method used by Rajan and Zingales (1998), a firm's dependence on external finance can also be captured by other measures. An alternative measure applied in the finance literature is the R&D intensity of a firm, calculated as the share of expenses for research and development $XRDS$ in total sales $SALE$ (Manova 2009, p.9). As before, the ratio refers to the technological aspects of a firm's production process. It should be noted, however, that oil and gas companies typically do not report R&D expenses. Therefore, for the oil and gas as well as the refineries sector, I use exploration expenses $OGXPX$ instead.[9]

[8] In 1987, firms started to report according to the Financial Accounting Standards No. 95 (FAS 95) and in 1992, companies introduced the International Accounting Standards (IAS) 7 format for cash flow statements (Meyer 2007, p.3).

[9] The use of this proxy is somewhat critical because its value depends on whether companies use the successful efforts or full cost accounting method. $OGXPX$ can only be used for firms that apply the successful efforts method and represents only expenses toward *unsuccessful* investment (Bryant 2003, p.12).

(6) Raddatz (2006) proposes another measure of a firm's need for external finance: the ratio of inventories to sales (in Compustat $INVT/SALE$). It captures the part of inventory investment that can be financed with ongoing sales. The ratio "proxies the delay between manufacturing and sales and [thus] the working capital [which] firms require in order to maintain inventories and meet demand" (Manova 2009, p.9). A high value represents, ceteris paribus, a rather high dependence on external finance, because only a small part of inventory investment can be financed with ongoing sales (Raddatz 2006, p.685). Generally, firms try to avoid having a lot of inventory for a long time since storage can be costly and ties up cash. Among the components of working capital investment, Raddatz (2006) considers inventories to be particularly well-suited to capture the technological characteristics of finance needs - more so, specifically, than liquid assets. He assumes that the inventory stock is renewed in each period, and that the longer the production process, the larger the value of inventories (p.685). This measure of financial dependence differs from the method used by Rajan and Zingales (1998). It captures the short-term finance needs of a company rather than its long-term requirements like the RZ measure. A potential problem is the fact that the ratio might be higher for the durable-goods sectors, and may thus not reflect pure finance needs but rather volatility, which is expected to be higher here. Raddatz (2006) shows, however, that this phenomenon is not relevant.

(7) A further measure of external dependence with a rather short-term focus is the ratio of short-term debt to sales (Raddatz 2006, p.686). As short-term debt is represented by notes payable, the calculation in Compustat mnemonics denotes $NP/SALE$. It captures the use of external finance and the ability of the company to pay its debt with ongoing earnings.

3.3 Sector Classification and Aggregation

I follow Rajan and Zingales (1998) in using the International Standard Industrial Classification Revision 2 (ISIC Rev.2). This allows my results to be compared to other results - that is, not only to those of Rajan and Zingales (1998) but to most of the works on finance that calculate measures of financial dependence. Since the Compustat database does not support ISIC Rev.2, the data classified by the North American Industrial Classification System (NAICS 2002) available in Compustat is converted to

ISIC Rev.2. This requires putting together a detailed correspondence table where 6-digit NAICS codes are matched with 4-digit ISIC Rev.3.1 codes and then with 3-digit ISIC Rev.2 codes (see Table A4). In some cases, a 4-digit ISIC Rev.2 code, e.g. for the motor-vehicles sector (3843), is used. This subsector is, therefore, not part of the 3-digit code which denotes, e.g. transport equipment (384). A total of 2,627 publicly listed U.S. firms across the natural-resource and manufacturing sectors is included in the analysis. The fishing and forestry industry as well as the pottery and leather industry have been excluded since they provide only few observations.

The above measures of external dependence are calculated for each firm in each period. Aggregation is then done in the following manner: the means of the annual figures within the desired period are taken, that is, 1980 to 1989, 1990 to 1999, 2000 to 2009, 1980 to 2009 and 1990 to 2009.[10] Using these ten- or twenty-year means of companies, I then take the median across firms for each sector. As a result, there is one coefficient per sector for each ten- or twenty-year period. Rajan and Zingales (1998) apply a similar method in order to avoid large fluctuations over time (p.564) and to obtain a measure that is representative for the industry and not too heavily influenced by outliers.

4 Results

Table 1 shows three out of the seven different measures of financial dependence in selected time periods: the original RZ measure (column 1), the RZ modification no. 3 (column 2) and inventories to sales (column 3). Obviously, the sectors differ significantly in their need for external finance. For example, the tobacco industry (ISIC 314) is largely independent of the financial infrastructure: a value of -5.11 (column 2) indicates that operative cash flow by far exceeds capital expenditures. In contrast, the communication-equipment sector (ISIC 3832) relies more heavily on external finance. With a value of 0.41 (column 2), its capital expenditures are higher than its operative cash flow. The sectors' ranking of financial dependence differs to a notable extent across the measures. The natural resource sectors seem to be relatively dependent on the financial system in column 2, but rather independent in column 3, which denotes inventories to sales. This becomes even more obvious in Table A1 where all measures

[10] As stated above, the specific use of a certain period depends on the measure of external dependence.

and sectors are depicted. It is, therefore, necessary to analyze in more detail how the different measures are correlated.

In the following, a possible monotonic relationship between the different measures, characterized by the correlation coefficient for linear correlation, is of primary interest, rather than absolute levels.

First, the original RZ measure is compared with the RZ modification no. 1. Both measures should be highly correlated since they are constructed in a very similar way. Using the same sample for the 1980s (excluding the natural resource sectors), gives a correlation of 0.59, which is less than expected. Presumably, this is due to a different method of calculating the change in inventories, payables and receivables - where Rajan and Zingales (1998) remain silent on the details - and due to a slightly different sector correspondence. The correlation of the original RZ measure (1980s) with the RZ-like variables for the 1990s is a bit smaller (not depicted in the tables).

Table 1
Financial Dependence across Sectors (Selected Measures and Sectors)

ISIC	Sector	Original RZ Measure	RZ Modification No. 3	Inventories to Sales
		1980-1989	1990-2009	1990-2009
		(1)	(2)	(3)
210	Coal mining	.	-0.24	0.05
220	Crude petroleum and natural gas production	.	0.58	0
311	Food products	0.14	-0.68	0.11
314	Tobacco	-0.45	-5.11	0.17
321	Textile	0.19	-1.04	0.16
353	Petroleum refineries	0.04	-0.45	0.06
371	Iron and steel	0.09	-0.44	0.16
383	Electric machinery	0.77	-0.37	0.18
3832	Communication equipment	1.04	0.41	0.16
3843	Motor vehicles	0.39	-0.21	0.12

(1) *Original RZ measure* from Rajan and Zingales (1998) and for some sectors from Kroszner, Laeven and Klingebiel (2007). (2) *RZ modification no. 3* is calculated as $(CAPX_t - OANCF_t)/CAPX_t$ where $CAPX$ denotes capital expenditures and $OANCF$ net cash flow from operative activities (in Compustat mnemonics). (3) The ratio of *inventories to sales* is calculated as $INVT/SALE$. Sector classification is ISIC Rev.2.

Next, I compare the measures that can be applied for the time period 1990-2009: RZ modifications nos. 2 and 3, R&D intensity, inventories to sales and short-term debt to

sales. Correlations are shown in Table A2. The RZ modifications nos. 2 and 3, which differ in the exact calculation of the operative cash flow, have a high correlation of 0.97. Both measures are highly correlated with the ratio of R&D expenses to sales (0.99). It should be kept in mind, however, that the latter measure relies on significantly fewer observations than the previous ones and that exploration expenses are only a rough proxy for the R&D intensity in the oil and gas production. The high correlations above are partly driven by the outlier sector 3522 (drugs), which has very high values here of financial dependence. Nevertheless, the positive and significant results generally hold, even if the drugs sector is excluded. In contrast, the ratio of inventories to sales is not correlated with one of the previous three measures (non-significant values of -0.20, -0.16 and -0.18). The same is true for the ratio of short-term debt to sales. Furthermore, inventories to sales and short-term debt to sales are not correlated either (not significantly different from zero with a value of 0.13). In the latter case, at least, the resource sectors' order in the ranking is relatively similar (Table A3).

How should these mixed results be interpreted? All measures claim to indicate a sector's dependence on external finance. While the RZ modifications and R&D intensity deliver similar results, inventories to sales and short-term debt to sales tend to contradict those measures. The ranking of the natural resource sectors, in particular, depends heavily on the measure applied. As can be seen in Table A3, the first measures indicate that these sectors are rather *dependent* on external finance in comparison to manufacturing industries. This finding contradicts the widespread opinion that natural resource sectors - notably crude oil and natural gas production - rely less on the financial system. However, measured by inventories to sales or short-term debt to sales, the mining, oil and gas sectors tend to be financially independent. Kroszner, Laeven and Klingebiel (2007) propose a possible explanation for the difference: the RZ-like variables are broader measures of financial requirements, which are appropriate for capturing the *long-term* dependence on external finance provided primarily by banks (p.203). In contrast, inventories to sales and short-term debt to sales measure the *short-term* financing of working capital. The authors assume that this capital may also be provided by other investors than banks. Thus, when using financial dependence as a building block in growth and trade analysis, one should carefully distinguish between long-term and short-term dependence.

With regard to natural resources, there is another aspect which needs to be considered.

Although mining sectors play an important role (e.g. in South Africa, Chile or Peru), the crude petroleum and natural gas production is the most interesting resource sector. A number of countries such as Saudi Arabia, Russia or Venezuela rely heavily on this specific export sector. Where do oil and gas show up in this paper's analysis? In principle, they are captured by the ISIC Rev.2 sector 220 called crude petroleum and natural gas production. Firms which produce crude oil and also have *refineries* are instead captured by the ISIC sector petroleum refineries (353). In my U.S. sample, the 353 industry includes companies such as ExxonMobil, Chevron and ConocoPhillips. As Tables A1 and A3 show, this sector is much less dependent on the financial infrastructure than sector 220, regardless of the measure. A factor that may drive this result is the well-known phenomenon of a life cycle in firms' financing (Rajan and Zingales 1998, p.565). Generally, young (or small) firms are more prone to rely on external investors than more mature and larger companies. Normally, this fact would not affect the above analysis since all sectors consist of both small and large firms. The firms captured by sector 353, however, can be considered to be larger than the companies in sector 220, which makes industry 353 relatively independent of external finance. Consequently, one has to keep in mind that a large part of the oil and gas production in the United States shows up in the manufacturing sector petroleum refineries (353).

5 Testing the Assumptions

Variation over time

An important question to be answered is whether the period chosen matters. Does the ranking change over time? Since the original RZ measure and the RZ modification no. 1 are available for the 1980s only, they are excluded here. But the correlations of time periods 1990-1999, 2000-2009 and 1990-2009 for the remaining five measures indicate that the ranking of industries is relatively stable (see Table A5). The RZ modification no. 3 and R&D intensity, in particular, show high and significant correlations (more than 0.96) between time spans.[11] The weakest correlation - showing up in the comparison between short-term debt to sales measured from 1990-1999 and 1990-2009 - is 0.59.[12] Therefore, Rajan and Zingales (1998) seem to be correct in their assumption

[11] Correlations are slightly lower if the drugs sector (3522) is excluded from the sample.

[12] In case of inventories to sales, Kahn, McConnell and Perez-Quiroz (2004) argue that the measure has been decreasing in recent decades because companies in all sectors have economized their inventory holdings. However, this does not affect the ranking itself.

that the sectors' ranking of external dependence does not change considerably over time.

Variation across countries

As stated in Section 3, the argument that the sectors' financial dependence differs due to inherent technological factors leads to another assumption: the results found for U.S. industries should be representative for industries in other countries. In other words, the order of the sectors ranked by their external dependence should not change considerably if non-U.S. data is used instead. This will be done in the following. Since Compustat North America provides only limited data for the rest of the world, the database Worldscope by Thomson Reuters is used.

There is only a limited number of countries that satisfy the necessary criteria for an analysis that resembles the one in the previous sections. In order to obtain the companies' unbiased demand for external finance, these countries should have a well-developed financial system with a sufficient supply of credit. Typically, this applies to countries in the Western hemisphere. Furthermore, there should be a considerable number of companies active in resource sectors. And, finally, the overall number of listed firms in the economy should be high, which is especially true in countries with an equity-based financial system. These criteria are satisfied by the United Kingdom, Australia and Canada.[13] In addition, an aggregate is constructed which merges the companies of these economies into a single sample. This ensures that small sectors also consist of a more appropriate number of firms.

Due to limited data availability in Worldscope, only two measures of financial dependence are used here: RZ modification no. 3 (with aggregate operative cash flow) and inventories to sales, with the former representing rather long-term and the latter rather short-term finance needs. Both measures are calculated exactly as before. RZ modification no. 3 is capital expenditures minus net cash flow from operations divided by capital expenditures (in Worldscope depicted by the mnemonics $WC04601$ and $WC04860$), and the ratio of inventories to sales is total inventories divided by net sales ($WC02101$ and $WC01001$). Following the previous procedure, the measures are calculated for each firm, taking the means of the annual figures and, finally, determining the median of each sector for the time periods 1990-1999, 2000-2009 and 1990-2009.

[13]The company lists are obtained in Worldscope with the mnemonics $FBRIT$, $FAUS$ as well as $FCDNX$ and $FTORO$.

The 1980s are excluded here since Worldscope provides only limited data before the early 1990s. Industry classifications are converted from SIC to ISIC Rev.2. The final dataset used in the analysis consists of 29 sectors.[14] The sample size is 454 companies for the United Kingdom, 403 for Australia, 690 for Canada, and, accordingly, 1,547 for the aggregate.

As a first robustness check, I test how the figures found with Compustat data correspond to those found with Worldscope data for the United States itself (Worldscope mnemonic *FUSA*, 630 firms). RZ modifications no. 3 from 1990 to 2009 from both databases show a significant correlation of 0.77 (not depicted in the tables). The two corresponding ratios of inventories to sales are significantly correlated with 0.78. These results are basically supported when the time period is varied (1990-1999 and 2000-2009). One might argue that the correlations should be even higher since the variables theoretically present the same measurement. However, Compustat and Worldscope do not provide entirely equal data. Both databases use insider information in addition to regular company reports and set up own unique consolidation standards. Besides, covered markets and time periods can differ. Especially for the 1990s, Compustat provides more data than Worldscope (Ulbricht and Weiner 2005). Compustat results may also differ from those obtained in Worldscope because NAICS data is matched to ISIC Rev.2 data for the former, and SIC data is matched to ISIC Rev. 2 data for the latter. It can nevertheless be concluded that measures obtained from Compustat and Worldscope are comparable.

With this result in mind, it is now possible to turn to the comparison between the measures of financial dependence across countries. Table A6 shows how RZ modification no. 3 (1990-2009) from Compustat for the United States is correlated with the corresponding Worldscope measure in the other countries: correlation with the United Kingdom is 0.53, with Australia 0.57, with Canada 0.84 and with the aggregate 0.80. All values are significant at the 1% level. The outcome for correlations between U.S. inventories to sales (1990-2009) from Compustat and the corresponding Worldscope measures is similar: with the United Kingdom 0.62, with Australia 0.29, with Canada 0.64 and with the aggregate 0.75. Except for Australia, all values are significant. For both measures, correlations *among* these countries are weaker, but they largely support

[14]The sectors tobacco (314), footwear (324), petroleum and coal products (354) as well as rubber products (355) provide only few data and are excluded here.

the positive and significant results.[15] Changing the time period to 2000-2009 shows no remarkable deviations from the previous outcomes. As expected, correlations for the period 1990-1999 are mixed due to poor data availability (not depicted in the tables). Also, it does not come as a surprise that Australia generally shows the least clear-cut results since the least amount of data is available for this country. In contrast, the aggregate with about 1,500 British, Australian and Canadian firms in one sample shows a high correlation with the U.S. Compustat data. As indicated above, the high number of companies ensures that smaller sectors such as wood products (331) also have a more representative value for their sectoral external dependence.[16]

As one can see, the overall ranking of sectors according to their level of financial dependence is similar across countries. Is this also true for the relative position of natural resource sectors? As in Section 4, natural resource sectors tend to be dependent on external finance when the measure relating capital expenditures and operative cash flow (RZ modification no. 3) is applied. In contrast, when measuring the more short-term liquidity needs with inventories to sales, these sectors appear to be far less dependent on external finance (not depicted in the tables). These results are essentially consistent with those from Section 4.

6 Conclusion

The finding of Rajan and Zingales (1998) that industries differ systematically in their reliance on the financial infrastructure has been widely applied in the growth and trade literature. However, the analysis has been restricted so far to manufacturing sectors. Arguing that natural resource sectors also play a role in the finance and trade/ growth analysis, this paper calculates these sectors' degree of financial dependence.

In addition to the original RZ measure, six variables have been constructed: three RZ modifications, which differ in the exact calculation of operative cash flow, as well as R&D intensity, inventories to sales and short-term debt to sales. It is shown that the different measures of external dependence are not perfectly correlated. While the RZ-like measures and R&D intensity deliver relatively similar results, the ratios of inventories to sales and short-term debt to sales show no correlation with the other

[15] Correlations are lower if the drugs sector (3522) is excluded from the sample. However, the overall results still hold.

[16] While the order of sectors appears to be positively correlated across countries, the absolute values may vary considerably.

variables. This is also true for the order of the natural resource sectors compared to manufacturing industries. The first five measures, which capture rather long-term finance needs, find that mining, oil and gas sectors are rather financially dependent. In contrast, the last two measures, which capture rather short-term liquidity needs, indicate that these industries rely *less* on the financial system. Thus, the results contradict the widespread opinion of researchers that natural resource sectors in particular are *generally* financially independent.

Furthermore, two major assumptions have been tested, which follow from the argument that sectoral external dependence is related to inherent technological characteristics. Indeed, the order of the sectors ranked by their financial dependence appears to be relatively stable over time and across countries.

7 Appendix

Table A1
Financial Dependence across Sectors (All Measures, Compustat)

ISIC	Sector	Original RZ Measure	RZ Modification No. 1	RZ Modification No. 2	RZ Modification No. 3	R&D Intensity	Inventories to Sales	Short-term Debt to Sales
		1980-1989	1980-1989	1990-2009	1990-2009	1990-2009	1990-2009	1990-2009
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
210	Coal mining	-	−0.23	0.22	−0.24	0.099	0.05	0.007
220	Crude petroleum and natural gas production	-	0.23	0.73	0.58	0.056	0.00	0.005
230	Metal ore mining	-	0.40	2.59	4.79	-	0.16	0.011
290	Other mining	-	−0.20	−0.32	−0.30	-	0.14	0.005
311	Food products	0.14	−0.44	−0.62	−0.68	0.004	0.11	0.018
313	Beverages	0.08	−0.14	−0.06	0.02	-	0.08	0.004
314	Tobacco	−0.45	−0.96	−1.17	−5.11	0.014	0.17	0.018
321	Textile	0.19	0.42	−1.29	−1.04	0.012	0.16	0.002
322	Apparel	0.03	−1.04	−1.68	−1.25	0.005	0.17	0.012
324	Footwear	−0.08	−0.60	−2.57	−2.34	0.009	0.20	0.016
331	Wood products	−0.76	-	−0.45	−1.33	0.007	0.10	0.015
332	Furniture	0.24	−0.87	−1.67	−2.24	0.007	0.11	0.006
341	Paper and products	0.17	−0.40	−1.00	−1.00	0.013	0.11	0.009
342	Printing and publishing	0.20	−1.23	−2.05	−2.06	0.011	0.05	0.002
351	Industrial chemicals	0.25	−0.70	−0.44	−0.38	0.015	0.10	0.011
352	Other chemicals	0.22	−0.33	−0.93	−0.92	0.026	0.13	0.030
3522	Drugs	1.49	1.11	31.37	38.16	2.560	0.08	0.002
353	Petroleum refineries	0.04	−0.41	−0.35	−0.45	0.009	0.06	0.002
354	Petroleum and coal products	0.33	−1.48	0.13	7.75	0.315	0.17	0.040
355	Rubber products	0.23	−0.26	−0.02	−0.01	0.026	0.15	0.164
356	Plastic products	1.14	0.19	−0.44	−0.37	0.011	0.12	0.160
369	Nonmetal products	0.06	−0.27	−0.24	−0.11	0.012	0.13	0.011
371	Iron and steel	0.09	−0.73	−0.23	−0.44	0.009	0.16	0.011
372	Nonferrous metal	0.01	0.42	−0.43	−0.19	0.009	0.14	0.015
381	Metal products	0.24	−0.60	−1.65	−1.45	0.008	0.14	0.011
382	Machinery	0.45	−0.53	−1.18	−0.84	0.024	0.18	0.015
3825	Office and computing	1.06	−0.25	0.41	1.11	0.156	0.13	0.009
383	Electric machinery	0.77	−0.28	−0.08	−0.37	0.053	0.18	0.014
3832	Communication equipment	1.04	0.41	0.33	−0.41	0.160	0.16	0.011
384	Transportation equipment	0.31	0.06	−0.35	−0.16	0.031	0.17	0.008
3843	Motor vehicles	0.39	0.39	−0.09	−0.21	0.023	0.12	0.011
385	Professional goods	0.96	0.34	1.87	0.54	0.139	0.19	0.016
390	Other industries	0.47	−0.35	−0.03	0.07	0.038	0.17	0.025

The table reports the values of all measures of financial dependence. (1) *Original RZ measure* from Rajan and Zingales (1998) and for some sectors from Kroszner, Laeven and Klingebiel (2007). (2) Written in Compustat mnemonics, *RZ modification no. 1* is $(CAPX_t - (FOPT_t - (INVT_t - INVT_{t-1}) - (RECT_t - RECT_{t-1}) + (AP_t - AP_{t-1})))/CAPX_t$ where $CAPX$ denotes capital expenditures, $FOPT$ total funds from operations, $INVT$ inventories, $RECT$ receivables and AP payables. (3) *RZ modification no. 2* is $(CAPX_t - (IBC_t + DPC_t + TXDC_t + ESUBC_t + SPPIV_t + FOPO_t + INVCH_t + RECCH_t + APALCH_t))/CAPX_t$ where IBC denotes income before extra items, DPC depreciation, $TXDC$ deferred taxes, $ESUBC$ equity in net loss, $SPPIV$ sale of fixed assets and investments loss, and $FOPO$ funds from other operations. $INVCH$, $RECCH$, $APALCH$ are the changes in inventories, receivables and payables. (4) *RZ modification no. 3* is calculated as $(CAPX_t - OANCF_t)/CAPX_t$ where $OANCF$ denotes net cash flow from operative activities. (5) *R&D intensity* is the share of expenses for research and development $XRDS$ (or exploration expenses $OGXPX$ for sector 220 and 353) in total sales $SALE$. (6) The ratio of *inventories to sales* is calculated as $INVT/SALE$. (7) The ratio of *short-term debt to sales* is $NP/SALE$ with notes payable NP. Sector classification is ISIC Rev.2.

Table A2
Correlations between Measures of Financial Dependence (Compustat)

	RZ Modification No. 2 1990-2009 (1)	RZ Modification No. 3 1990-2009 (2)	R&D Intensity 1990-2009 (3)	Inventories to Sales 1990-2009 (4)	Short-term Debt to Sales 1990-2009 (5)
RZ-Modification No. 2	1				
RZ-Modification No. 3	0.97**	1			
R&D Intensity	0.99**	0.99**	1		
Inventories to Sales	-0.20	-0.16	-0.18	1	
Short-term Debt to Sales	-0.08	-0.06	-0.10	0.13	1

The table reports the correlations between selected measures of financial dependence. (1) In Compustat mnemonics, *RZ modification no. 2* is $(CAPX_t - (IBC_t + DPC_t + TXDC_t + ESUBC_t + SPPIV_t + FOPO_t + INVCH_t + RECCH_t + APALCH_t))/CAPX_t$ where IBC denotes income before extra items, DPC depreciation, $TXDC$ deferred taxes, $ESUBC$ equity in net loss, $SPPIV$ sale of fixed assets and investments loss, and $FOPO$ funds from other operations. $INVCH$, $RECCH$, $APALCH$ are the changes in inventories, receivables and payables. (2) *RZ modification no. 3* is calculated as $(CAPX_t - OANCF_t)/CAPX_t$ where $OANCF$ denotes net cash flow from operative activities. (3) *R&D intensity* is the share of expenses for research and development $XRDS$ (or exploration expenses $OGXPX$ for sector 220 and 353) in total sales $SALE$. (4) The ratio of *inventories to sales* is calculated as $INVT/SALE$. (5) The ratio of *short-term debt to sales* is $NP/SALE$ with notes payable NP. ** indicates significance at the 1 % level.

Table A3
Ranking of Sectors (Selected Measures of Financial Dependence, Compustat)

RZ Modification No. 3 (1)	R&D Intensity (2)	Inventories to Sales (3)	Short-term Debt to Sales (4)
Tobacco	Food products	**Crude petroleum and natural gas**	Textile
Footwear	Apparel	Printing and publishing	**Petroleum refineries**
Furniture	Furniture	**Coal mining**	Drugs
Printing and publishing	Wood products	**Petroleum refineries**	Printing and publishing
Metal products	Metal products	Beverages	Beverages
Wood products	Iron and steel	Drugs	**Crude petroleum and natural gas**
Apparel	Nonferrous metal	Industrial chemicals	**Other mining**
Textile	**Petroleum refineries**	Wood products	Furniture
Paper and products	Footwear	Furniture	**Coal mining**
Other chemicals	Printing and publishing	Paper and products	Transportation equipment
Machinery	Plastic products	Food products	Office and computing
Food products	Textile	Plastic products	Paper and products
Petroleum refineries	Nonmetal products	Motor vehicles	Communication equipment
Iron and steel	Paper and products	Nonmetal products	Industrial chemicals
Industrial chemicals	Tobacco	Office and computing	Metal products
Plastic products	Industrial chemicals	Other chemicals	Nonmetal products
Electric machinery	Motor vehicles	Metal products	**Metal ore mining**
Other mining	Machinery	**Other mining**	Iron and steel
Coal mining	Rubber products	Nonferrous metal	Motor vehicles
Motor vehicles	Other chemicals	Rubber products	Apparel
Nonferrous metal	Transportation equipment	**Metal ore mining**	Electric machinery
Transportation equipment	Other industries	Iron and steel	Nonferrous metal
Nonmetal products	Electric machinery	Textile	Wood products
Rubber products	**Crude petroleum and natural gas**	Communication equipment	Machinery
Beverages	**Coal mining**	Other industries	Footwear
Communication equipment	Professional goods	Apparel	Professional goods
Other industries	Office and computing	Tobacco	Food products
Professional goods	Communication equipment	Transportation equipment	Tobacco
Crude petroleum and natural gas	Petroleum and coal products	Petroleum and coal products	Other industries
Office and computing	Drugs	Machinery	Other chemicals
Metal ore mining	Beverages	Electric machinery	Petroleum and coal products
Petroleum and coal products	**Other mining**	Professional goods	Plastic products
Drugs	**Metal ore mining**	Footwear	Rubber products

The table reports the ranking of natural resource and manufacturing sectors for selected measures of financial dependence (in ascending order). (1) *RZ modification no. 3* is calculated as $(CAPX_t - OANCF_t)/CAPX_t$ where $CAPX$ denotes capital expenditures and $OANCF$ net cash flow from operative activities (in Compustat mnemonics). (2) *R&D intensity* is the share of expenses for research and development $XRDS$ (or exploration expenses $OGXPX$ for sector 220 and 353) in total sales $SALE$. (3) The ratio of *inventories to sales* is calculated as $INVT/SALE$. (4) The ratio of *short-term debt to sales* is $NP/SALE$ with notes payable NP. Sector classification is ISIC Rev.2.

Table A4
Correspondence Table for Compustat Data (Natural Resource Sectors)

ISIC Rev.2 3-digit	Sector	NAICS 2002 6-digit	Sector
210	Coal mining	212111	Bituminous coal surface mining
		212112	Bituminous coal underground mining
		212113	Anthracite mining
		213113	Anthracite coal recovery from culm banks and other contract or fee services to coal mining
		324199	Hard-coal fuel briquettes
		212111	Lignite surface mining
		324199	Lignite fuel briquettes
		2121	Coal mining
		21211	Coal mining
220	Crude petroleum and natural gas production	211111	Liquefying and extracting coal
		211111	Extraction of crude petroleum and natural gas
		211112	Extraction of natural gas liquids
		488999	Liquefaction and regasification of natural gas for transport
230	Metal ore mining	212210	Iron ore mining and/or beneficiating
		212291	Uranium mining and/or beneficiating
		212299	Thorium mining and/or beneficiating
		212221	Gold mining and/or beneficiating
		212222	Silver ore mining and/or beneficiating
		212231	Lead and zinc ore mining and/or beneficiating
		212234	Copper and nickel ore mining and/or beneficiating
		212291	Vanadium and radium mining and/or beneficiating
290	Other mining	212311	Mining or quarrying or building or monument stone, mining or quarrying slate
		212312	Crushed and broken limestone, dolomite, and chalk
		212313	Crushed or broken granite
		212319	Crushed or broken marble, slate, or stone (except bituminous limestone, bituminous sandstone, and mica schist)
		212321	Quarrying sand or gravel for construction
		212322	Mining or quarrying industrial sand
		212324	Mining or kaolin and ball clay
		212325	Mining of ceramic and refractory clays including bentonite
		212399	Gypsum, alabaster, pulpstone, millstone, and grindstone mining, other crushed stone
		212391	Quarrying or mining of potash, soda, and borite minerals
		212392	Quarrying or mining of phosphate rock
		212393	Quarrying or mining other chemical or fertilizer minerals, such as lithium, arsenic and barium
		311942	Mining and processing of table salt
		212399	Peat mining, digging or beneficiating in combination with mining

6-digit NAICS 2002 codes are matched with 4-digit ISIC Rev.3.1 and then with 3-digit ISIC Rev.2 codes. This list includes only natural resource sectors. A similar correspondence table was established for the 29 manufacturing sectors (available on request).

Table A5
Test of Assumption 1: Variation over Time (Compustat)

RZ Modification No. 3	1990-1999	2000-2009	1990-2009
	(1)	(2)	(3)
1990-1999	1		
2000-2009	0.96**	1	
1990-2009	0.96**	0.99**	1

R&D Intensity	1990-1999	2000-2009	1990-2009
	(1)	(2)	(3)
1990-1999	1		
2000-2009	0.99**	1	
1990-2009	0.99**	0.99**	1

Inventories to Sales	1990-1999	2000-2009	1990-2009
	(1)	(2)	(3)
1990-1999	1		
2000-2009	0.93**	1	
1990-2009	0.96**	0.97**	1

Short-term Debt to Sales	1990-1999	2000-2009	1990-2009
	(1)	(2)	(3)
1990-1999	1		
2000-2009	0.84**	1	
1990-2009	0.59**	0.70**	1

The table reports the correlations between the time periods for which the selected measures of financial dependence are calculated. (1) *RZ modification no. 3* is calculated as $(CAPX_t - OANCF_t)/CAPX_t$ where $CAPX$ denotes capital expenditures and $OANCF$ net cash flow from operative activities. (2) *R&D intensity* is the share of expenses for research and development $XRDS$ (or exploration expenses $OGXPX$ for sector 220 and 353) in total sales $SALE$. (3) The ratio of *inventories to sales* is calculated as $INVT/SALE$. (4) The ratio of *short-term debt to sales* is $NP/SALE$ with notes payable NP. ** indicates significance at the 1 % level.

Table A6

Test of Assumption 2: Variation across Countries (Compustat and Worldscope)

RZ Modification No. 3	United States	United Kingdom	Australia	Canada	Aggregate (UK, Australia, Canada)
	Compustat 1990-2009 (1)	Worldscope 1990-2009 (2)	Worldscope 1990-2009 (3)	Worldscope 1990-2009 (4)	Worldscope 1990-2009 (5)
United States	1				
United Kingdom	0.53**	1			
Australia	0.57**	0.30	1		
Canada	0.84**	0.41*	0.64**	1	
Aggregate (UK, Australia, Canada)	0.80**	.	.	.	1

Inventories to Sales	United States	United Kingdom	Australia	Canada	Aggregate (UK, Australia, Canada)
United States	1				
United Kingdom	0.62**	1			
Australia	0.29	0.29	1		
Canada	0.64**	0.47*	0.45*	1	
Aggregate (UK, Australia, Canada)	0.75**	.	.	.	1

The table reports the correlations between the regions' values for sectors' external dependence. *RZ modification no. 3* is calculated in Compustat as $(CAPX_t - OANCF_t)/CAPX_t$ where $CAPX$ denotes capital expenditures and $OANCF$ net cash flow from operative activities. In Worldscope, it is calculated as $(WC04601 - WC04860)/WC04601$. The ratio of *inventories to sales* is in Compustat $INVT/SALE$ and in Worldscope $WC02101/WC01001$. ** indicates significance at the 1 % level. * indicates significance at the 5 % level.

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