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# Energy costs and export competitiveness: evidence from Australian industries

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## Abstract

Energy costs' impact on industrial competitiveness is not well known in Australia. This paper investigates this question empirically by undertaking a two-part analysis. First, the impact of energy price changes on industrial energy efficiency is tested using Australian data from 2002–03 to 2013–14. The short-term energy efficiency response is found to be small, on average, across 1-digit industries. But rather than an inefficient price mechanism, it is more a reflection of the difficulty in immediately changing energy use behaviour. The energy efficiency response is expected to be larger over longer time periods and for more energy intensive sectors, though data limitations prevented this from being tested definitively. The second part of this paper tests whether energy costs impact on export competitiveness. No discernible effect is found for a selection of 1-digit industries. However, when the focus shifts to more energy intensive manufacturing industries, a rise in energy costs is shown to have a small detrimental impact on export competitiveness, as measured by revealed comparative advantage (RCA). The significance of energy costs to export competitiveness is generally overshadowed by other factors.

**JEL Codes:** P18, Q4

**Keywords:** Energy, Competitiveness, Energy costs, Energy intensity, Energy efficiency, Energy prices, Revealed Comparative Advantage



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## Key points

- Energy costs are comparatively low for the Australian economy as a whole, but more prominent and rising for certain industries like manufacturing.
- Australian industries respond to energy price increases by improving their energy efficiency by a small amount in the short term.
- Rather than an inefficient price mechanism, the small energy efficiency response reflects that it is difficult to immediately change energy use behaviour in the face of unexpected energy price rises.
- The small short term energy efficiency response means that rising energy prices lead to an increase in energy costs — the energy efficiency response is not sufficient to fully offset the price rise.
- The energy efficiency response is expected to be larger over the long term, and for higher energy intensive sub-industries. Inadequate data prevents this from being tested adequately.
- Rising energy costs have a small detrimental impact on the export competitiveness of Australian manufacturing industries. There is no effect discernible for less energy intensive sectors.

# 1. Introduction

Energy is a fundamental input to production. But the extent to which energy — and specifically, the cost of energy — impacts on competitiveness is not well known in Australia. This paper seeks to answer this question empirically.

International evidence finds that energy costs are eclipsed by other cost categories when investigating competitiveness.<sup>1</sup> But energy costs are likely to have a large impact on the competitiveness of energy intensive industries. Similarly, energy costs are likely to have a greater impact on competitiveness if they continue to rise (energy costs relative to other costs are currently rising for certain industries like manufacturing in Australia).

To determine the competitiveness impact in Australia, this paper adopts the methodology of *Energy Efficiency and EU Industrial Competitiveness: Energy Costs and their Impact on Manufacturing Activity* by the Vienna Institute.<sup>2</sup>

The Vienna Institute's report conducts a cross-country study on the manufacturing industry to investigate whether:

1. energy price shocks drive energy efficiency improvements
2. energy intensity or energy costs impact on manufacturing export competitiveness, as measured by revealed comparative advantage (RCA).

For this paper, we conduct a similar investigation for a broader range of industries, but for Australia only. The aim is to inform current and future energy policy by providing evidence about whether energy price rises drive firms and industry to improve energy efficiency. And whether or not energy costs impact on the ability of Australian industries to compete in international markets.

The investigation has particular relevance now that the United Nations Conference of Parties (COP) 21 Paris Agreement has been entered into force.<sup>3</sup> Australia's energy policy development will require continued efforts to reduce carbon emissions, alongside an understanding of how energy cost changes impact Australian industries. Understanding what drives improvements in energy efficiency is also important in this context.

The sections of this paper are organised as follows. Section 2 provides an overview of the different aspects of energy that are used to test the energy-competitiveness relationship. The aspects are energy costs, energy intensities and energy prices. Section 3 establishes estimates for the price elasticity of different energy intensities; or whether there is an energy efficiency response to energy price changes in Australia. Section 4 explores whether energy costs or energy intensity levels have an impact on the export competitiveness of Australian industries. Section 5 offers a conclusion.

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<sup>1</sup> See for example Sato M and Dechezlepretre A (2016) and Horvath A (2014)

<sup>2</sup> Astrov V et al. (2015)

<sup>3</sup> 2015 United Nations Climate Change Conference, held in Paris, France, from 30 November to 12 December 2015, and entered into force 4 November 2016.

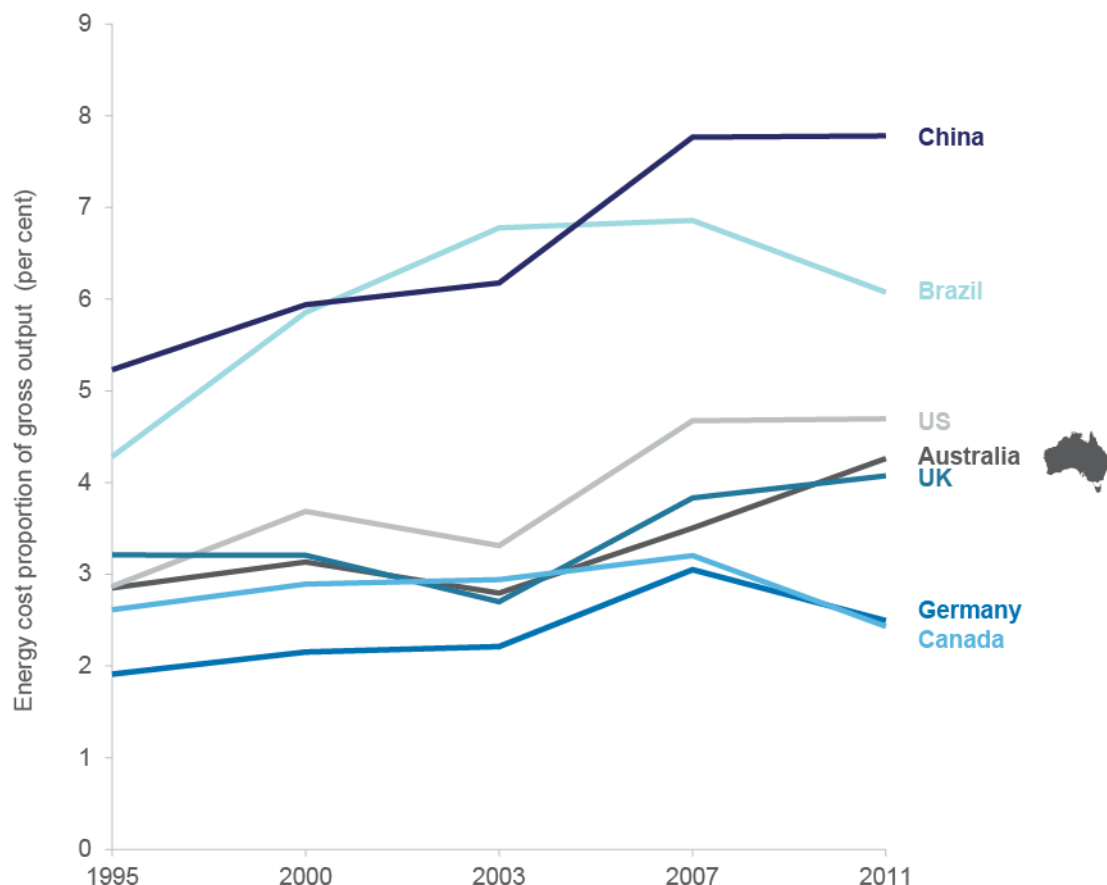
## 2. The energy landscape

This section includes a discussion of energy costs, energy intensities and energy prices. Each are used in the analyses conducted in Section 3 and Section 4.

### 2.1 Energy costs

Changes in energy costs provide a direct link to ideas of competitiveness. All else equal, rising energy costs imply that a firm or industry is becoming less competitive compared to similar firms or industries. From a whole of economy perspective, the magnitude of energy costs are largely dependent on the types of industries that make up the economy. Advanced, service-based economies — such as Australia and the UK — have lower proportional energy costs than more heavy-industry based economies like China (Figure 2.1). In addition to the structural composition of an economy, the type of energy generation (the energy mix) impacts on energy cost levels as well.

Figure 2.1: Energy costs as a percentage of gross output, Australia and selected countries, 1995 to 2011

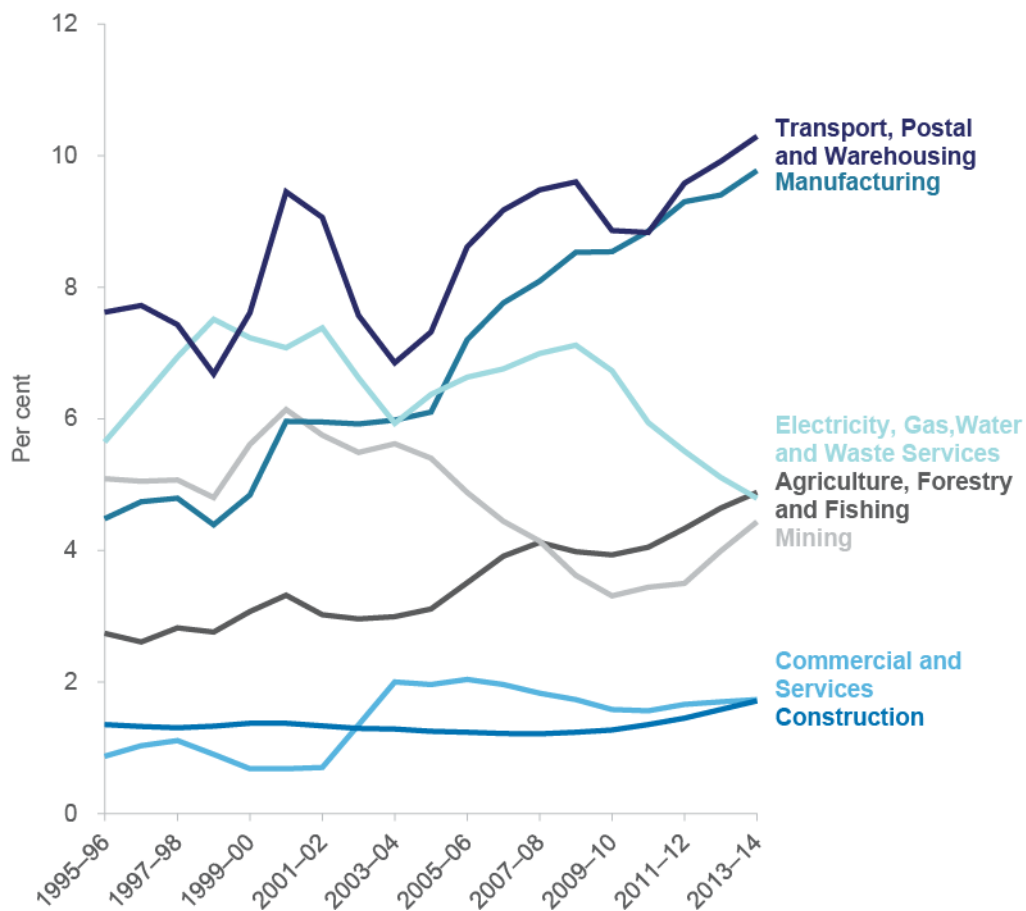


Source: World Input Output Database (WIOD)

The comparison of country energy costs is made possible using the *World Input Output Database (WIOD)*.<sup>4</sup> However, data is only available up to 2011. Since 2011 commodity prices have fallen, partly driven by a large increase in the supply of energy, including the ‘shale gas boom’. These developments have led to a fall in overall energy costs for certain countries.

Estimates for Australian industrial energy costs since 2011 are available from the ABS; new experimental estimates of Capital, Labour, Energy, Materials and Services (KLEMS). For certain industries (such as those in Commercial & Services and Construction) energy costs are small and relatively unchanged over time (see Figure 2.2). But energy costs as a proportion of total input costs for manufacturing and transport, postal & warehousing increased to around 10 per cent in 2013–14.

Figure 2.2: Energy cost as a proportion of capital, labour, energy, materials and services (KLEMS) input costs, 1-digit industries 1995–96 to 2013–14



Source: ABS cat. no. 5260.0, *Experimental Estimates of Industry Level KLEMS Multifactor Productivity, 2013–14*

Within these 1-digit industry groups, certain sub-industries can have an even higher proportion of energy costs. KLEMS data is unavailable beyond 1-digit industries, but electricity and natural gas inputs can be calculated relative to an

<sup>4</sup> Timmer M et al. (2015)

output measure using ABS input-output tables.<sup>5</sup> For instance, electricity and natural gas inputs to basic non-ferrous metal manufacturing were equal to 76 per cent of its Gross Value Added (GVA) in 2013–14. Other energy-intensive sub-industries are forged iron and steel product manufacturing; pulp, paper and paperboard manufacturing; and natural rubber product manufacturing.

An analysis shows that the most energy intensive manufacturing industries account for 23 per cent of manufacturing GVA in 2014–15.<sup>6</sup> While an analysis of Australia's merchandise exports shows that energy intensive industries account for over 43 per cent of the value of merchandise exports in 2015–16.<sup>7</sup>

Notwithstanding high energy cost sub-industries, aggregate energy costs for the economy as a whole remain low (especially in comparison to other cost categories like labour). The WIOD shows that Australia's energy inputs have increased from three per cent of gross output in the mid-1990s to just above four per cent in 2011.<sup>8</sup> The KLEMS data tells a similar story.

## 2.2 Energy intensities

Improvements in energy efficiency at the economy and industry levels are typically tracked by measures of energy intensity. In this paper, energy intensity is defined as energy product (total energy, electricity or natural gas) used per unit of real GVA.<sup>9</sup> This calculation yields energy intensity, electricity intensity and natural gas intensity. In general, high levels of these different energy intensities are associated with low levels of energy efficiency and *vice versa*. The benefit of analysing energy intensity (rather than energy use or energy efficiency) is that output produced per unit of energy is easily comparable across countries or industries.

However, it is not a direct measure of energy use or energy efficiency; improvements in energy intensity are not necessarily due to improvements in energy efficiency. It may be due to a changed structural composition of the economy (to less energy intensive industries) or a changed level of real output.<sup>10</sup> Care is needed when interpreting changing energy intensity in the context of energy efficiency.

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<sup>5</sup> ABS cat. no. 5209.0.55.001, *Australian National Accounts: Input-Output Tables 2013–14*, Table 2

<sup>6</sup> 3-digit manufacturing industries in ABS cat. no. 8155.0 were assumed to be energy intensive if energy inputs were greater than 10 per cent of their GVA using ABS cat. no. 5209.0 (the energy-inputs-to-GVA cut-off of 10 per cent identified 12 of 51 manufacturing industries).

<sup>7</sup> Eight out of 26 merchandise export groups in ABS cat. no. 5368.0, Table 32a were identified as energy intensive by cross referencing similar industries using ABS cat. no. 5209.0.55.001 and calculating their energy inputs relative to GVA.

<sup>8</sup> Timmer M et al. (2015)

<sup>9</sup> Electricity and natural gas are the two main final (or end-use) energy sources used by Australian industry (aside from oil derived fuels) and form the basis of analysis later in the chapter.

<sup>10</sup> Stanwix G et al. (2015), p. 1

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## Box 2.1: Energy concepts and definitions

Measuring energy-use and energy intensity is multifaceted. The two main sources of energy data in this paper are the ABS *Energy Account, Australia* (EAA) and the *Australian Energy Statistics* (AES) produced by the Department of Industry, Innovation and Science.<sup>11</sup> These two publications are related, though the information conforms to different standards. Important aspects of each are discussed within this box.

From a statistical standpoint, measuring energy incorporates physical supply and use, monetary supply and use, consumption of natural resources, and a consistent approach to reconcile or balance these frameworks. The System of Environmental-Economic Accounting (SEEA) is the standard used by most statistical agencies to report energy statistics. For instance, the ABS EAA transforms AES data using the SEEA framework to enable linkages between energy supply, energy use and the system of national accounts.<sup>12</sup>

In the guide to the AES, “energy commodities are either extracted or captured directly from natural resources (primary fuels), or by transforming primary fuels into other energy sources (secondary or derived) fuels. Secondary fuels can also be derived from other secondary fuels.”<sup>13</sup> This distinction is important because it leads to the concept of net energy use — a useful estimate of the amount of energy used by an industry to produce its output.

The two net energy concepts are EAA net energy use and AES total final energy consumption. Both are similar. The difference is that EAA net energy use conforms to the SEEA standard in its treatment of distribution and extraction losses and own use of energy within industries. The EAA conformity with SEEA means that it is the preferred data source for analysis in this paper — the relationship between energy price and energy intensity is derived with EAA data. But AES energy consumption data is also used to enable a critical look at the energy-competitiveness relationship over a longer time period than provided by the ABS.<sup>14</sup>

An additional distinction between the AES and EAA measures relates to how energy use or consumption is allocated to industry. For the AES, land transport fuels are assigned by activity rather than ‘industry of ownership’. From the ABS: “fuel used by a truck owned by a mining company and operating between mining sites would likely be treated as transport activity in AES but an industry-based view would assign this use to the mining industry.”<sup>15</sup>

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<sup>11</sup> ABS cat. no. 4604.0 *Energy Account Australia*, Explanatory Notes, 2013–14 and Department of Industry and Science (2015)

<sup>12</sup> United Nations (2012)

<sup>13</sup> Department of Industry and Science (2015)

<sup>14</sup> ABS energy intensities cover the years 2002–03 to 2013–14 while AES energy consumption is available from 1973–74 to 2013–14 for many industries.

<sup>15</sup> ABS cat. no. 4604.0



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### Box 2.1: Energy concepts and definitions (continued)

This treatment can lead to significant differences in derived estimates of fuel use and industry-based energy intensities between the two source measures. Differences are largest for construction, transport, and commercial & services. Accordingly, analysis using AES does not look at the aforementioned industries — the focus is mainly on manufacturing.

Another concept with relevance to this paper relates to the energy supply chain and the point at which measurement takes place. Total final energy consumption (AES) and domestic net energy consumption (EAA) are measurements taken at the end of the supply chain — relevant for energy 'used' by industry. Whereas energy supply typically relates to the beginning of the supply chain, before distribution, extraction and conversion. Electricity and natural gas are prominent forms of end-use or final energy consumption — the focus of this paper.

Electricity and natural gas are the two main end-use energy sources in Australia, aside from oil derived fuels. In 2013–14, electricity accounted for 23 per cent of net energy use by industry, while natural gas accounted for 21 per cent.<sup>16</sup> In manufacturing, these percentages increase to 24 per cent and 40 per cent, respectively.<sup>17</sup> Each of these specific energy intensities (energy intensity, electricity intensity and natural gas intensity) are used for the price elasticity analysis in Section 3.

## 2.3 Energy prices

Price variables are incorporated to enable the estimation of the price elasticity of energy intensity. This is able to show the extent to which industries are able to improve their energy efficiency (as proxied by energy intensity) in response to energy price rises.

Sourcing appropriate price data, particularly to the industry level, has been challenging. Part of this difficulty is due to energy contracts between firms and energy providers being confidential. The Australian Energy Market Operator (AEMO) and International Energy Agency (IEA) provide aggregate indices, but these are less useful for a study of effects at the industry level.

Another challenge with energy price data is that firms often enter multi-year energy contracts, so may be relatively unaffected by short-term price fluctuations. This characteristic manifests in both industry and sub-industry price indices.

The price data used for the analysis in this paper was sourced from the ABS (by special request) for the years 2002–03 to 2013–14. The data are nominal price indices for 1-digit, and some 2-digit, Australia and New Zealand Standard Industrial Classification (ANZSIC) industries.

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<sup>16</sup> *ibid*

<sup>17</sup> Natural gas is used as a material rather than energy input by some manufacturing industries. But it was not possible to remove this contribution from the subsequent energy analysis.

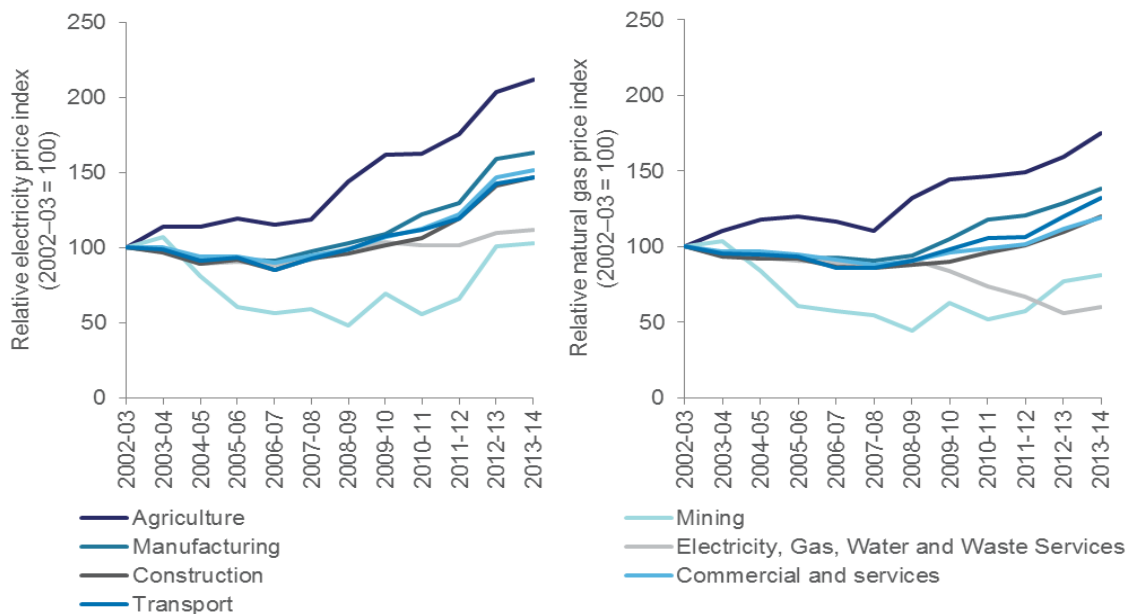
An initial investigation shows that aggregate industrial prices for electricity have outpaced the consumer price index (CPI) for Australia by a factor of three. In contrast, aggregate industrial natural gas prices have more closely tracked CPI.

But before analysing the extent to which the price of energy impacts energy intensity/efficiency, prices need to be transformed to better reflect cost relative to output — consistent with the Vienna Institute paper methodology. This is because it is the proportional cost share that is the greater consideration for business.

Dividing the nominal price indices by industry output price deflators accounts for this. The end result is the relative energy price which is a better reflection of how much of an energy price increase (or decrease) is being absorbed by the industry in the form of an increased (or decreased) cost, relative to output.

For most industries, the price of energy relative to the price of industry output has increased substantially for electricity, and to a lesser extent, natural gas. But the trend for the mining industry is somewhat contrary to this trend (Figure 2.3). The initial decline in relative energy prices meant that energy costs were decreasing in prominence for the mining industry, despite an increase in the underlying nominal price index. This trend has reversed in the last five years, with relative energy prices rising in line with other industries. Much of the decrease in relative energy price occurred due to the large increase in the value of output for the mining industry as part of the resources boom.<sup>18</sup>

Figure 2.3: Relative electricity and natural gas price indices for 1-digit industries, 2002–03 to 2013–14



Source: ABS special request; Department of Industry, Innovation and Science (DIIS) calculations

<sup>18</sup> Downes P et al. (2014)

Another exception to the trend is the recent decline in the natural gas relative price for electricity, gas, water & waste services. This corresponds with a relatively flat underlying natural gas price index (a small increase much smaller than CPI) for this industry and rising output growth. Exceptions aside, the most recent five years of data show large increases in relative energy prices for most industries — in some cases, increases of more than 50 per cent.

The three components discussed — energy costs, energy intensity (proxy for energy efficiency) and energy prices — informs the analysis that follows.

### 3. The price elasticity of energy intensity

The first aspect of the analysis in this paper involves modelling the impact of relative energy prices on energy intensity. The primary goal is to estimate the price elasticity of energy intensities — specifically electricity intensity, natural gas intensity and energy intensity. The sign and magnitude of this estimate will show whether industries are able to improve their energy efficiency in response to energy price rises.

#### 3.1 Methodology

Data availability is a limiting factor for this analysis, with annual price data obtained from the ABS only spanning twelve years. This time period is too short to draw robust and meaningful conclusions for individual industries. To overcome this, the analysis is undertaken on a panel of seven 1-digit industries and, separately, four 2-digit manufacturing groups.

Energy use is publicly available net energy use provided within the ABS EAA and discussed in Box 2.1. The price indices are reliant on data compiled within the EAA though it is not publicly available.

To mitigate endogeneity, all of the explanatory and control variables are lagged by one year.<sup>19</sup> This also reflects the idea that changes in the energy price will not immediately translate to changes in energy intensity/use behaviour. That is, firms will find it difficult to immediately change their energy intensity and/or improve their energy efficiency in response to a change in price.

The control variables are similar to those used in the Vienna Institute paper. Capital intensity, or capital per employee, is included because capital intensive industries are more likely to be energy intensive. A linear time trend variable is also included to account for any general trend in energy intensity over time. There is generally a downward trend in energy intensity over time as all firms adopt new technology and become more energy efficient.

An output gap control variable is also incorporated in some models, though its explanatory power is lacking. This is because periods of strong growth are likely to lead to higher energy use and also higher output, with this having an uncertain impact on energy intensity. Carbon tax and global financial crisis

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<sup>19</sup> The endogeneity problem involves a change in price driving a change in energy intensity, but also *vice versa*. This two-way relationship means that the initial change in either variable then brings about a secondary response in the other variable, and so on.

dummy variables are also incorporated, though these prove to have little explanatory power in multiple alternative specifications of the model.

The baseline model is:

$$\ln(\text{Energy use}(e)_{it}/\text{GVA}_{it}) = \alpha_0 + \alpha_1 \ln(\text{RP}_{it-1}^e) + \alpha_2 \ln(K_{it-1}) + \text{time\_trend}_t + \text{output\_gap}_t + \text{GFC}_t + \text{CT}_t + \gamma_i + \varepsilon_{it} \quad (1)$$

Where:

*i* is the industry

*e* is the energy product — total energy, electricity or natural gas

*t* is the financial year

GVA<sub>it</sub> is Gross Value Added in constant prices

RP<sub>it</sub> is the relative price index for either electricity or natural gas

K<sub>it</sub> is capital stock per employee

time\_trend<sub>t</sub> is a linear vector of integers 1, 2, 3,...

output\_gap<sub>t</sub> is deviation of actual GDP from potential GDP as per cent of potential GDP obtained from the OECD

GFC<sub>t</sub> and CT<sub>t</sub> are global financial crisis and carbon tax dummy variables

γ<sub>i</sub> captures the unique aspects of industry *i* (only for fixed effects models)

ε<sub>it</sub> is the error term

The 'ln' designation means that the variable has been converted to a logarithmic value.

Both fixed effects and random effects assumptions are used for the above model. Tests tended to show that random effects assumption were more appropriate for the 1-digit panel whereas fixed effects assumptions were more appropriate for 2-digit manufacturing.

The specification as defined is able to deliver the price elasticity of energy intensity in the short run. Replacing the price variable by a lagged 5-year moving average, for example, can deliver a 5-year price elasticity of energy intensity. But in doing so for analysis with this data, too many observations are lost for the findings to be meaningful. A lagged 3-year moving average was used as a compromise, though these results were not particularly strong and are not reported.

To conduct the 2-digit manufacturing analysis, capital intensity was calculated using wages and salaries per employee as a proxy.<sup>20</sup> This is because capital stock is not available to the 2-digit level.

### 3.2 Results for 1-digit industry panel

The seven industries in the 1-digit analysis are: agriculture; mining; manufacturing; electricity, gas, water & waste services; construction; transport; commercial & services.

Electricity intensity and natural gas intensity are the main dependent variables used in the 1-digit models. This is because price changes for a specific energy type are only likely to have a subdued impact on total energy use.

The impact of relative electricity and natural gas prices on overall energy intensity (instead of electricity intensity and natural gas intensity) was tested, but did not return statistically significant results.

In addition to the refined focus, agriculture was removed from the panel analysis. This is because energy use estimates for agriculture are not as robust or dependable as for other industries.

The first aspect of the analysis to report is that many alternative specifications of this model still returned statistically insignificant results. This could be due to any or all of the following characteristics. First, current electricity and natural gas prices may not have a meaningful impact on the amount of energy that firms choose to consume in Australia — at least at the 1-digit industry level analysed here. Second, it's possible that the data we have is not adequate to identify the underlying relationship. Lastly, the estimation techniques in this analysis may not be sufficient to model the relationship.

For models that did uncover a relationship, the results show that the short-term price elasticity of electricity intensity for 1-digit industries is smaller than those uncovered by the Vienna Institute.<sup>21</sup> But this is almost certainly due to the inclusion of non-energy intensive industries such as those found in commercial & services.

The coefficients on price reported in Table 3.1 show that a 10 per cent increase in the relative electricity price led to a reduction in electricity intensity of roughly 1.0 to 1.3 per cent. Statistical significance was lacking for multiple models not reported, though the coefficients remained similar in magnitude.

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<sup>20</sup> Wages and salaries per employee is used as a proxy for capital intensity on the assumption that high wages and salaries are associated with higher capital stock. This relationship holds for 1-digit manufacturing for the years 2002–03 to 2013–14 with a correlation coefficient of 0.96.

<sup>21</sup> Astrov V et al. (2015)

Table 3.1: Estimation results for electricity intensity in the short run, 1-digit selected models

<i>Dependent variable: Ln electricity intensity</i>				
	Random effects (a)		Random effects (b)	
<i>Ln relative electricity price<sub>t-1</sub></i>	-0.099	*	-0.133	***
<i>Ln capital intensity<sub>t-1</sub></i>	0.431	***	0.449	***
<i>Time trend</i>	-0.015	**	-0.018	***
<i>Output gap<sub>t-1</sub></i>			-0.016	
<b>Constant</b>	4.28	***	4.34	***
<b>R<sup>2</sup> (within variation)</b>	0.36		0.37	
<b>R<sup>2</sup> (between variation)</b>	0.43		0.43	
<b>R<sup>2</sup> (Overall)</b>	0.43		0.43	
<b>N</b>	66		66	

Source: Department of Industry, Innovation and Science (2016)

For models (a) and (b) the time trend was statistically significant and negative, as expected. This captures the consistent trend of declining electricity intensity over time. Part of this is a result of growth in real GVA outpacing growth in energy use.<sup>22</sup> Capital intensity was also statistically significant for most models, and positive as expected. That is, more capital intensive industries are characterised by higher energy intensities. The output gap did not prove to have explanatory power relating to changing levels of energy intensity.

Moving to natural gas specifications, the relative natural gas price series was found to be non-stationary. To overcome this, models were estimated in first-differences (growth rate when the variables are log values) rather than levels.<sup>23</sup> A similar negative relationship is found with statistically significant relative natural gas price coefficients of -0.14 and -0.15, respectively (see Table 3.2). This means that for a ten per cent increase in the growth of the relative natural gas price, the natural gas intensity growth rate decreases by roughly 1.5 per cent.

<sup>22</sup> Stanwix G et al. (2015)

<sup>23</sup> The coefficient on price is now interpreted slightly differently: it is the change of the growth in natural gas intensity with respect to a change in the growth of the relative price.

Table 3.2: Estimation results for natural gas intensity in the short run, 1-digit selected models

<i>Dependent variable: <math>\Delta \ln</math> natural gas intensity</i>		
	Random effects (c)	Random effects (d)
$\Delta \ln$ relative natural gas price <sub>t-1</sub>	-0.136 ***	-0.154 ***
$\Delta \ln$ capital intensity <sub>t-1</sub>		0.090
Time trend	0.008	0.008
<b>Constant</b>	-0.09	-0.09
<b>R<sup>2</sup> (within variation)</b>	0.08	0.08
<b>R<sup>2</sup> (between variation)</b>	0.14	0.16
<b>R<sup>2</sup> (Overall)</b>	0.07	0.07
<b>N</b>	60	60

Notes:  $\Delta$  designates change

Source: Department of Industry, Innovation and Science (2016)

But including control variables lacked explanatory power for these models. In general, the results are not as telling as those uncovered for electricity. Still, the short-term results are consistent with a recent cross-country study which finds a high price responsiveness for natural gas demand, albeit in the long-run.<sup>24</sup>

To test the robustness of the data and the results, the specifications were altered to account for alternative energy inputs. Both relative prices (i.e. natural gas and electricity) were incorporated to explain electricity intensity, and similarly, natural gas intensity. The expectation is that an increase in the price of the alternative energy will drive an increase in intensity for the other energy source. For example, an increase in the relative electricity price would drive an increase in natural gas intensity — indicated by positive price coefficients.

For electricity intensity models, the sign of the coefficient on the relative electricity price remained negative, while the sign of the coefficient on the differenced relative natural gas price was positive. But coefficients were only sometimes statistically significant, depending on which control variables were used. Results for natural gas intensity were inconclusive.

Long-term relative price elasticities will provide better evidence of the ability of industries' to switch energy sources, but Australian data is not yet available to test this at the 1-digit industry level.

### 3.3 Results for 2-digit manufacturing groups

Data for an amalgam of four manufacturing sub-industries was constructed to undertake this analysis. The groups were (i) food, beverages and textiles (ii) wood, paper and printing (iii) petroleum and chemical products (iv) metal and other manufacturing.

<sup>24</sup> Burke P and Hewen Y (2016)

These groups allow a refined focus on industries that are some of the most energy intensive, where energy costs are much more likely to drive changes in energy intensity. However, the number of observations are a limiting factor in this analysis. Multiple variables are also non-stationary, meaning the models were largely estimated using first differences.

One of the first aspects of these results that stands out is that the relative price had a statistically significant impact on overall energy intensity. This is in contrast to the 1-digit results where no robust relationship was found on energy intensity (only electricity intensity and natural gas intensity). But this may be because electricity and natural gas contribute a much larger share to manufacturing's total net energy use when compared to the economy as a whole.<sup>25</sup>

The impact of relative natural gas prices and relative electricity price on energy intensity was much larger than for the 1-digit analysis. The two models reported in Table 3.3 show that for a 10 per cent increase in the growth of relative electricity or relative natural gas price, growth of energy intensity declines by between 4.9 and 6.0 per cent.<sup>26</sup> This is a very large short-term effect, but is in line with expectations that energy prices matter more for energy intensive industries.

Table 3.3: Estimation results for energy intensity in the short run, 2-digit manufacturing selected models

<i>Dependent variable: <math>\Delta \ln</math> energy intensity</i>		
	Fixed effects (e)	Fixed effects (f)
<i><math>\Delta \ln</math> relative electricity price<sub>t-1</sub></i>	-0.600 **	
<i><math>\Delta \ln</math> relative natural gas price<sub>t-1</sub></i>		-0.485 ***
<i>Time trend</i>	-0.012 *	0.005
<b>Constant</b>	-0.04	-0.02
<b>R<sup>2</sup> (within variation)</b>	0.18	0.10
<b>R<sup>2</sup> (between variation)</b>	0.93	0.87
<b>R<sup>2</sup> (Overall)</b>	0.10	0.12
<b>N</b>	40	40

Notes:  $\Delta$  designates change

Source: Department of Industry, Innovation and Science (2016)

But these results are not particularly robust. Firstly, the sample size is small. And secondly, the inclusion of control variables used in the 1-digit analysis did not have any explanatory power in multiple alternative specifications (the

<sup>25</sup> In 2013–14, the combined electricity and natural gas net energy use for Manufacturing was 64 per cent, compared to 44 per cent across all industries (ABS cat. no. 4604.0)

<sup>26</sup> Unlike the 1-digit analysis, fixed effects assumptions were the most appropriate model specifications.



specification is likely to be inadequate). The results remain preliminary until they can be substantiated by data that allows a more thorough investigation.

There were also no statistically significant results found for electricity intensity models or for models which incorporated the alternative price of energy.<sup>27</sup>

In sum, the results show that energy intensity improvements — particularly for the 1-digit analysis — do not fully offset the impact of rising relative electricity and natural gas prices in the short term. This means that energy costs rise when energy prices rise. But the mostly small negative relationship is consistent with other research.<sup>28</sup> Small elasticities are more an indication of the difficulty in changing short-term behaviour, rather than an inefficient price response. This is substantiated by studies that find larger effect sizes for the long term.<sup>29</sup>

## 4. The impact of energy on competitiveness

The results in the previous section pointed to a small short-term response of energy intensity to energy price changes. This paper now turns to an exploration of whether increasing energy costs have an impact on competitiveness.

But measuring competitiveness is difficult. One method of measurement involves using export data and RCA, and this is what is used here (consistent with the Vienna Institute report).

### 4.1 Methodology

RCA is an applied use of comparative advantage theory. It compares export volumes for specific industries or products/services of a domestic economy to the share of those same industries or products/services in world trade. Values greater than one imply a comparative advantage, with change over time showing changing levels of competitiveness.

The principle explanatory variable used to explain changes in RCA (competitiveness) is energy intensity — higher energy intensity implies more energy use and higher energy costs. ABS KLEMS estimates of energy cost are also used in its place for 1-digit models. These two alternative variables allow for a direct measure of the relative size of energy costs similar to what was being captured with relative price.

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<sup>27</sup> Natural gas energy use data is not available for enough of the 2-digit manufacturing groups to test elasticities on natural gas intensity.

<sup>28</sup> Astrov V et al. (2015)

<sup>29</sup> *ibid*

For control variables, labour productivity is included given its established link with competitiveness.<sup>30</sup> Capital intensity and wages and salaries are also incorporated, as per the Vienna Institute paper.

In addition, the chapter expands the specification by including the price of energy for Australian industry relative to the energy price for OECD countries. A higher ratio implies that Australia has higher energy costs and *vice versa*.

The total model is as follows:

$$\begin{aligned} Comp_{it} = & \alpha_0 + \alpha_1 \ln(enint_{it}) + \alpha_2 \ln(labprod_{it}) + \alpha_3 \ln(Kpc_{it}) \\ & + \alpha_4 \ln(wsal_{it}) + \alpha_5 \ln(ausoecd\_enprice_t) + GFC_t + CT_t \\ & + \gamma_i + \varepsilon_{it} \end{aligned} \quad (2)$$

Where:

i is the industry

t is the financial year

Comp<sub>it</sub> is the comparative advantage of industry i in year t as measured by RCA or exports

enint<sub>it</sub> is the value of energy intensity. This variable is replaced by energy cost share percentages of total KLEMS input costs for certain 1-digit specifications.

labprod<sub>it</sub> is the value of labour productivity — industry GVA divided by industry hours worked

Kpc<sub>it</sub> is capital intensity or capital per employee

wsal<sub>it</sub> is wages and salaries per employee

ausoecd\_enprice<sub>t</sub> is the ratio of Australian energy prices for industry to OECD energy prices

GFC<sub>t</sub> and CT<sub>t</sub> are global financial crisis and carbon tax dummy variables

γ<sub>i</sub> captures the unique aspects of industry i (fixed effects model assumption)

ε<sub>it</sub> is the error term

The 'ln' designation means that the variable has been converted to a logarithmic value. And similar to the price elasticity analysis in Section 3, the model was tested using both random effects and fixed effects assumptions.

The alternative specifications of this model provide insight into whether energy costs or energy intensity is impacting on the competitiveness of Australian industry.

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<sup>30</sup> See for example Auzina-Emsina A (2014)

## 4.2 Results for 1-digit industries

The main finding for the 1-digit panel is that multiple different specifications did not deliver statistically significant results. This is consistent no matter which primary explanatory variable is used — energy intensity or energy cost share of input costs (KLEMS) — or whether the dependent variable is RCA or exports.<sup>31</sup>

The lack of results is symptomatic of the data limitations. One such limitation is that reliable RCA data could only be sourced for goods based exports (services are not captured). This leaves agriculture, mining and manufacturing as the only industries that can be analysed.

Given this constraint, analysis of this smaller panel is not possible using ABS EAA energy intensities because the time series is too short. But AES energy consumption data is used to construct a longer time series of energy intensity for analysis.<sup>32</sup> For models that use energy intensity to explain changes in RCA, data is available from 1992–93 to 2013–14.<sup>33</sup> Models that use energy cost shares as the main explanatory variable incorporate data from 1995–96 to 2013–14.

Weak relationships are perhaps due to the inclusion of industries that are less energy intensive than manufacturing. As shown earlier in Figure 2.2, manufacturing had one of the highest KLEMS energy cost proportions, near 10 per cent in 2013–14. In contrast, agriculture and mining had a lower cost proportion of less than 5 per cent in 2013–14. This is likely to mean that energy is less important, from a competitiveness standpoint, for these industries.

As mentioned, no reportable relationship was found. However, results from other studies using cross-country energy analyses do not typically find strong impacts on competitiveness.<sup>34</sup> The absence of statistically significant results for this 1-digit analysis is consistent with these findings.

## 4.3 Results for 2-digit manufacturing groups

To determine whether there is a relationship within higher energy-intensive industries, the analysis was extended to a panel of manufacturing sub-industries. These were similar to the groups in the price elasticity analysis and were (i) food, beverages and textiles (ii) wood, paper and printing (iii) petroleum and chemical products (iv) metal and other manufacturing.

Statistically significant results were not found in a specification in levels. But a differences (growth) model specification showed a negative relationship between energy intensity and RCA. Table 4.1 shows that a 10 per cent increase

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<sup>31</sup> Specifications in levels and first differences were tested.

<sup>32</sup> Department of Industry, Innovation and Science (2015)

<sup>33</sup> A comparison of the ABS and AES energy intensity series' shows that they are broadly consistent in trend for the overlapping time period of 2002–03 to 2013–14. Differences between AES energy consumption and ABS *Energy Account, Australia* net energy use are discussed in Box 1

<sup>34</sup> For example Astrov V et al. (2015)

in growth of energy intensity leads to a reduction in growth of roughly 0.01 in RCA — depending on control variables used.<sup>35</sup> This is a small, but statistically significant result. In general, the impact of energy intensity on competitiveness is overshadowed by other factors that influence export competitiveness.

Table 4.1: Energy intensity and industrial competitiveness as measured by RCA, 2-digit manufacturing selected models

<i>Dependent variable: Δ RCA</i>					
	Random effects (g)		Random effects (h)		Random effects (i)
<i>Δ In energy intensity</i>	-0.087	***	-0.112	***	-0.095 **
<i>Δ In labour productivity</i>	0.137		0.095		
<i>Δ In capital intensity</i>	-0.310	**			-0.257 *
<i>Δ In ausoecd energy price</i>	-0.158	***	-0.111	***	-0.159 ***
<b>Constant</b>	-0.005		-0.014	*	-0.004
<b>R<sup>2</sup> (within variation)</b>	0.16		0.12		0.13
<b>R<sup>2</sup> (between variation)</b>	0.02		0.02		0.02
<b>R<sup>2</sup> (Overall)</b>	0.14		0.10		0.12
<b>N</b>	84		84		84

Notes: Δ designates change

Source: Department of Industry, Innovation and Science (2016)

The controls for these models returned coefficients that were consistent with the cross-country manufacturing analysis by the Vienna Institute. For instance, an increase in labour productivity is associated with an improvement in RCA in models (g) and (h), but it is not statistically significant. In contrast, increases in capital intensity for these manufacturing groups is associated with a statistically significant reduction in competitiveness.

Finally, the relative price of energy in Australia is statistically significant in all three reported models. It shows that a 10 per cent increase in the growth of Australia's energy price relative to the rest of the world is associated with a reduction in growth of RCA of between 0.01 and 0.02 for 2-digit manufacturing groups.

The impact of these associations with RCA appear small. But in the context of small RCA values for manufacturing, the magnitude of the change is more significant. All four of the manufacturing 2-digit groups had RCA values significantly less than one in 2013–14 (three of the four groups had RCA values less than 0.5). There is also a persistent downward trend from 2000 onwards, which aligns with the onset of the mining boom. Thus, a 0.01 movement when RCA is already much smaller than one, is more substantial than it first appears.

Most of the results for this section did not uncover a statistically significant energy-competitiveness relationship at the 1-digit industry level. But when the focus shifts to more energy intensive manufacturing industries, a relationship

<sup>35</sup> For example, for model (g),  $-0.087 \cdot \ln(1.1) = -0.008$  which is close to 0.01.

is borne out by the data. A better understanding of the strength of the relationship will require improved data sets, with longer time series, that are currently unavailable.

## 5. Conclusion

This paper has shown that energy costs are comparatively low for the Australian economy as a whole, but more prominent and rising for certain industries like manufacturing. In order to test whether energy costs impacts on the competitiveness of Australian industries, a two-part investigation was undertaken.

First, industrial energy prices were used to explain changes in the energy intensity (proxy for energy efficiency) of Australian industries for the period 2002–03 to 2013–14. Energy efficiency responses to energy price rises were generally small across 1-digit industries in the short term. But this is in line with expectations; it is difficult for firms' to immediately improve their energy efficiency in response to energy price rises. The small response can also be attributed to the inclusion of low energy cost industries such as those in commercial and services.

The small short term energy efficiency response means that rising energy prices lead to an increase in energy costs — the energy efficiency response is not sufficient to fully offset the price rise.

A larger energy intensity response to energy price changes is expected over the long term and for an investigation that specifically targets high energy-intensive sectors. A specific focus on manufacturing industries did uncover a larger response size, but improved data sets are required to test this definitively.

The second aspect of this paper involved testing whether or not energy costs had an impact on competitiveness, as measured by RCA. An effect was not discernible for 1-digit industries. But when honing in on more energy intensive manufacturing industries, a small statistically significant effect was uncovered; for a 10 per cent increase in the growth of energy intensity, the growth of RCA of these manufacturing groups fell by roughly 0.01.

In essence, rising energy costs have a small detrimental impact on the export competitiveness of Australian manufacturing industries (other factors tend to overshadow the impact of energy on competitiveness). The effect is likely to be larger for more energy intensive sub-industries, though data is currently unavailable to test this relationship adequately.

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