Factors influencing the Australian Wool Price

September 2024

Episode 3

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Table of Contents

Table of Figures

Scope

The Eastern Market Indicator (EMI), as a proxy for the broader Australian wool market, is largely unchanged from the same period a decade ago. This demonstrates that wool prices have not kept up with inflation, whilst wool producer costs have increased over this time frame.

Australian wool producers would benefit from increased margins, either from higher farmgate returns through improved wool prices or more on farm efficiency gains to be able to produce wool in amore cost effective manner.

This report focuses upon the key factors that drive Australian wool price trends to help producers understand what factors are most likely to contribute to improved farm gate returns via stronger wool prices.

This report will include the following analysis:

- A comparison of Australian wool price trends to other fibres.
- A comparison of Australian wool price trends versus wool production.
- A comparison of Australian wool price trends to lead economic indicators.
- An assessment of the impact of the wool marketing spend on the EMI.
- The development of an economic regression model that outlines the key drivers of Australian wool pricing. The Eastern Market Indicator (EMI) will be used as a benchmark Australian wool price indicator for the purpose of this report.

Wool Price Comparisons

Annual average price trends for the Eastern Market Indicator (EMI) versus South African wool prices[1], converted into Australian dollar terms, from 1990 to 2023 demonstrates a close relationship in price levels and directional trend.

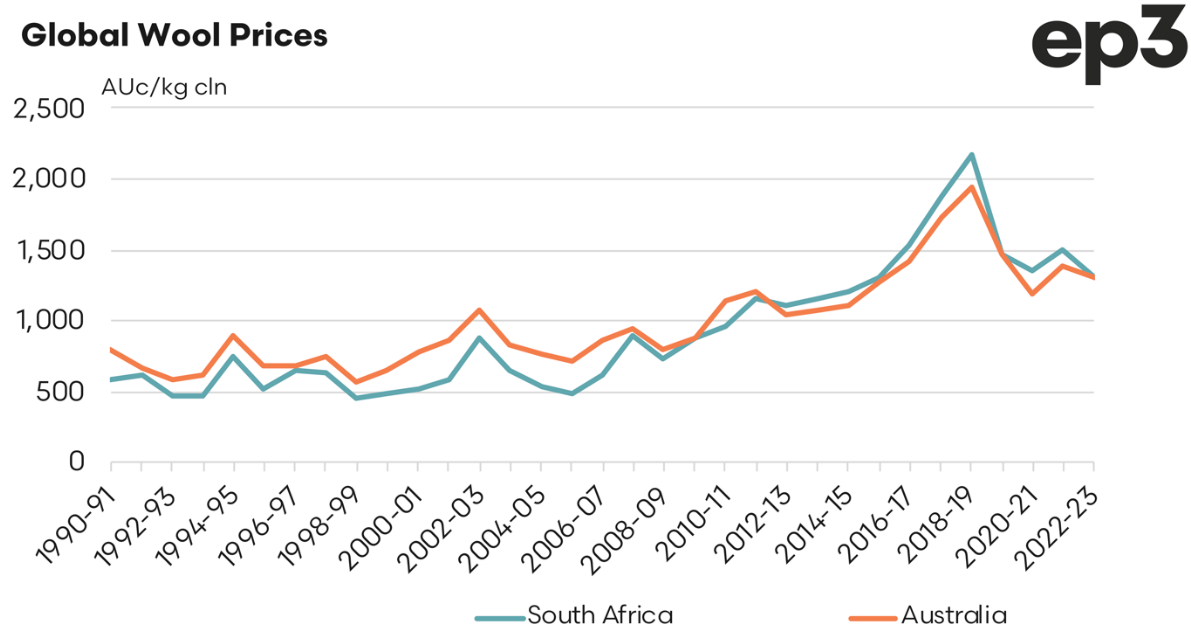

Figure 1 Global Wool Prices

From 1990 to 2013 Australian wool prices exhibited a price premium to South African wool. However, since 2013 the South African wool price has moved to a premium to the EMI.

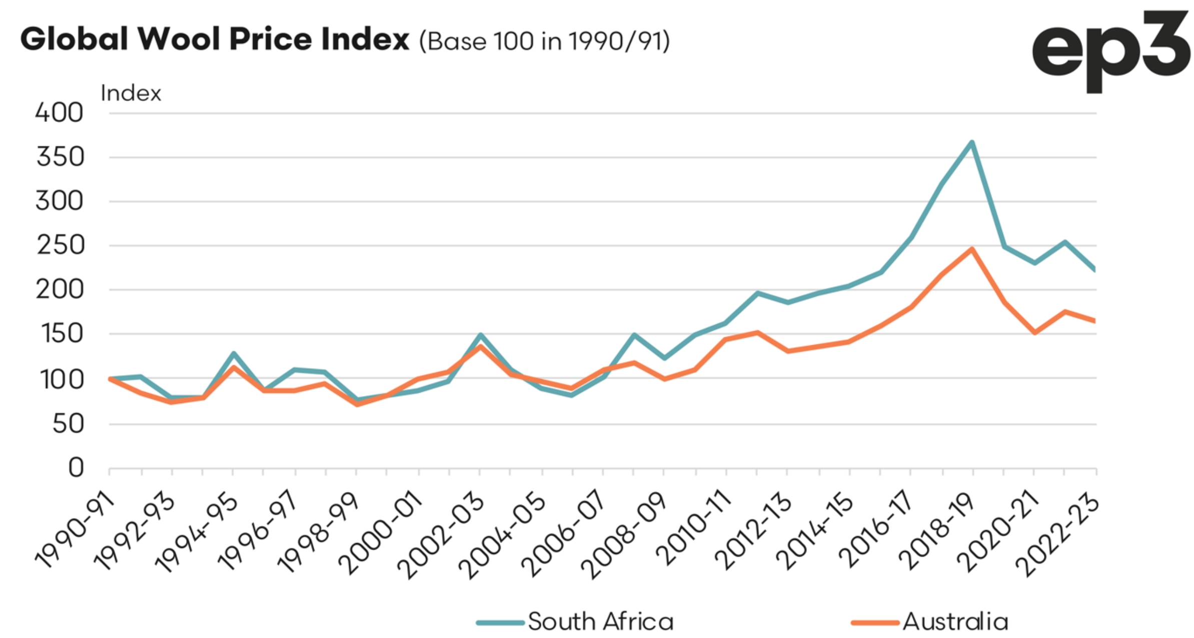

Figure 2 Global Wool Price Index

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[1] SA wool prices sourced from IWTO, SA Cape Wool - All Wool Price Indicator as an annual average and converted into A$ terms with reference to the annual average AUD/ZAR exchange rate.

Figure 2, above, highlights the two wool prices as an index (set at 100 in 1990/91) and demonstrates that during 1990 to 2007 the two indicators moved in close unison and at similar $A price levels. During 2007 to 2018 South African wool prices increased at a stronger rate than the EMI and moved to a premium to Australian wool price levels.

A scatter plot simple regression analysis of annual average prices from 1990/91 to 2022/23 for the EMI versus South African wool prices demonstrates a very high Pearson's R^2 correlation coefficient score of 0.9552, indicative of a strong relationship between the two price indicators.

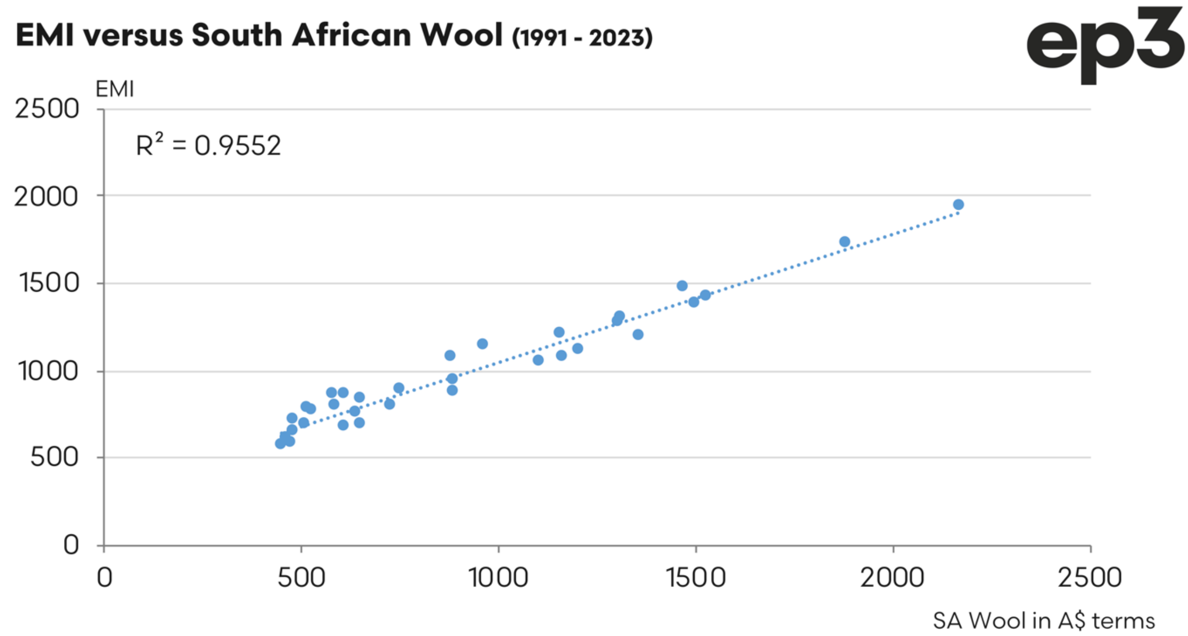

Figure 3 EMI versus South African Wool

The Pearson's correlation coefficient (denoted as R^2) measures the strength and direction of the linear relationship between two variables. This coefficient measures the proportion of the variance in one variable that is explained by the variance in the other.

Similarly, measuring the correlation between the EMI and South African wool with regard to annual price change confirms a strong correlation in annual price directional trend with a coefficient score of 0.6865, as outlined in Figure 4 below.

For an R^2 of 0.6865, this means that 68.65% of the variation in one price indicator can be explained by the variation in the other price indicator. This suggests that about 70% of the variation in the EMI annually is associated with changes in South African wool prices, and vice versa. It implies that the two prices tend to move together most of the time, but not always.

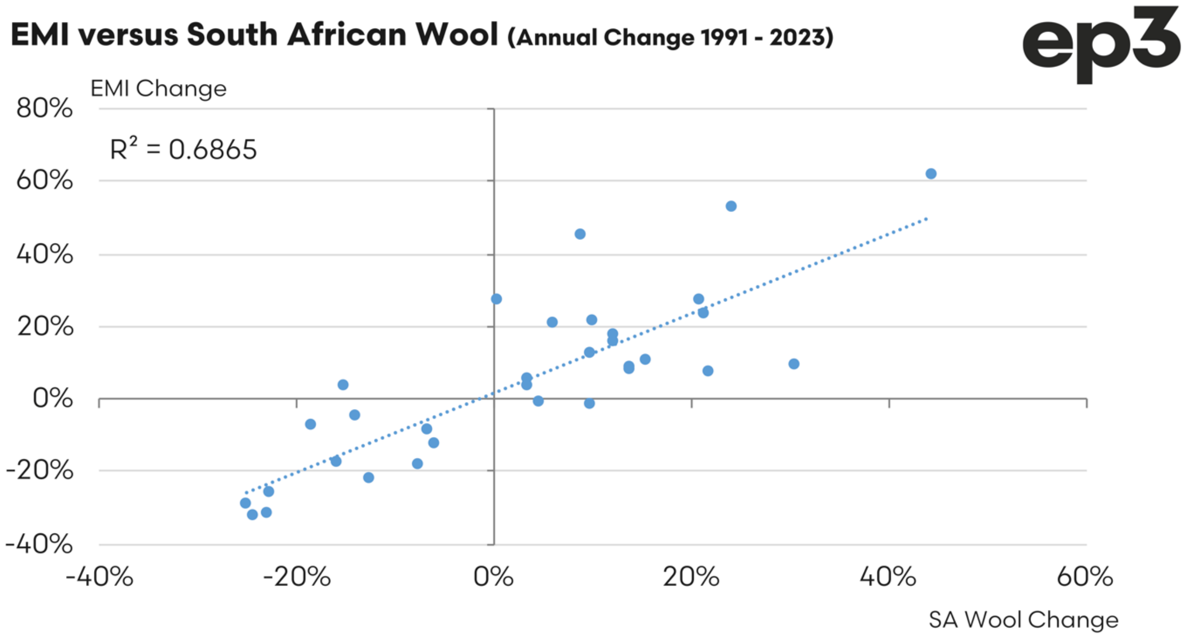

Figure 4 EMI versus South African Wool, Annual Change

A comparison of the EMI to other fibres also shows some moderately strong correlations when it comes to annual price change. The annual price variation between the EMI and global average cotton prices is demonstrated in Figure 5, below.

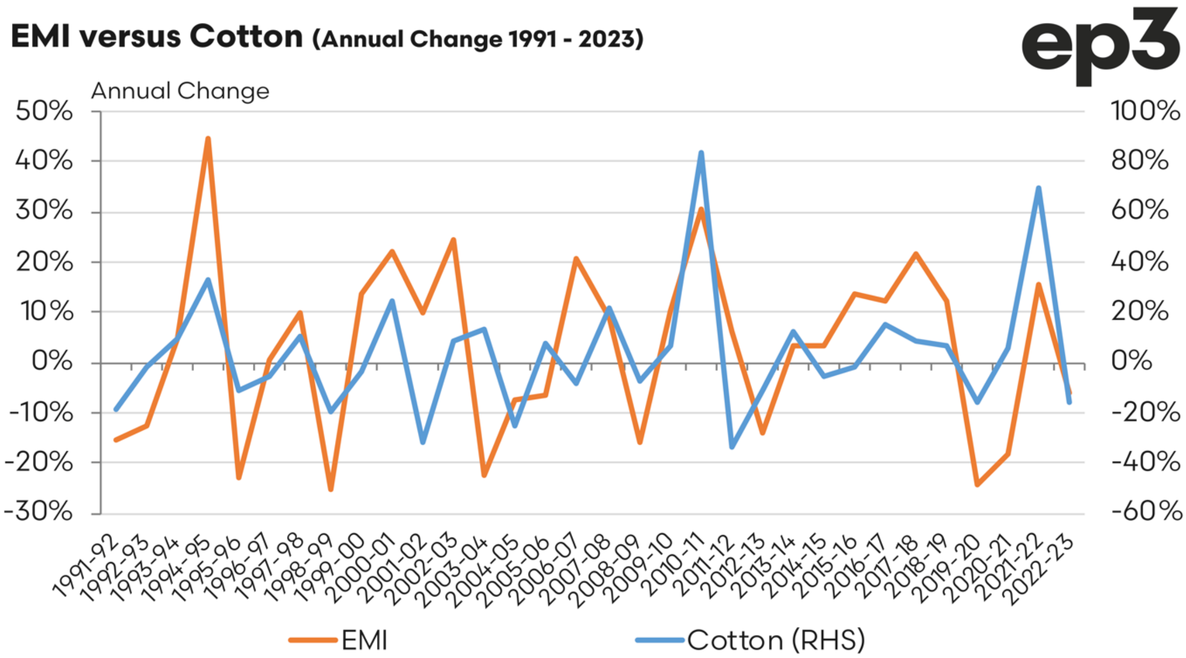

Figure 5 EMI versus Cotton, Annual Change

While cotton price changes, in percentage terms, tends to range more widely than the EMI they both tend to move in the same direction more broadly over time, suggesting similar global factors may be influencing the price trends for these two fibres.

An assessment of the annual change of the EMI to Cotton prices using the Pearson's R^2 measure demonstrates that the relationship is moderately strong with a coefficient of

0.2821. This suggests that nearly a third of the time the variation in the EMI is influenced by the same or similar factors that impact the broader fibre market, such as the market for cotton.

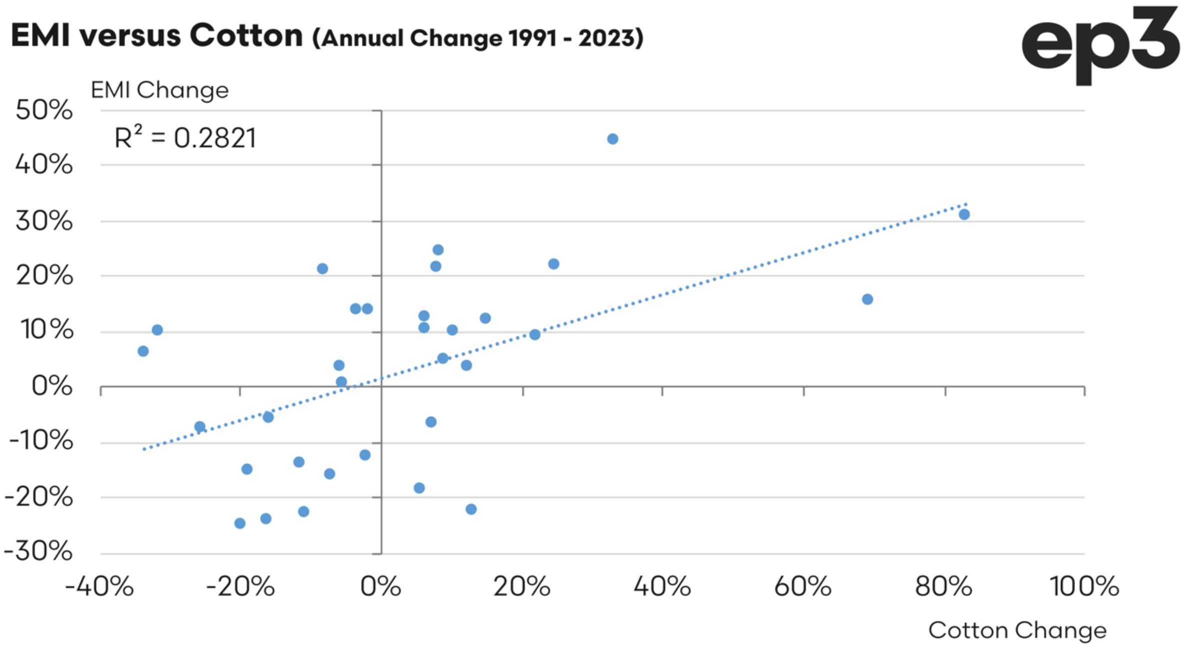

Figure 6 EMI versus Cotton, Annual Change

Similarly, extending beyond the fibre market to the global market for raw materials we can see that the EMI price relationship to the Raw Materials Index[2] is of a similar moderate strength to the cotton indicator with a Pearson's coefficient of 0.258.

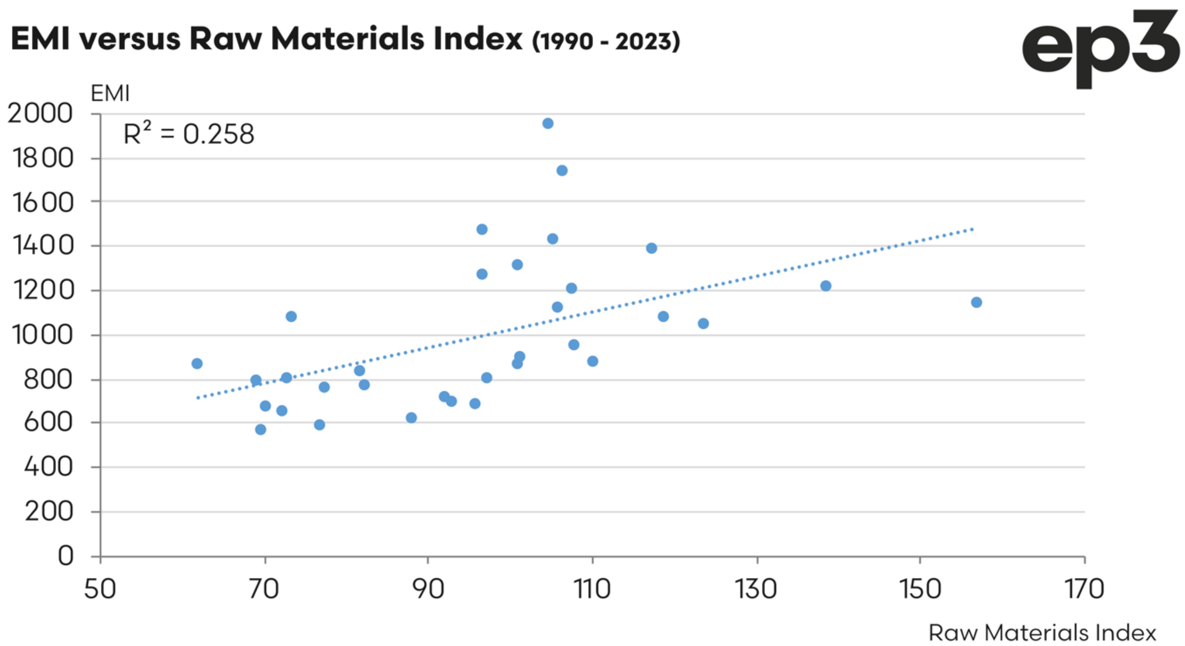

Figure 7 EMI versus Raw Materials Index

The global Raw Materials Index represents the prices of a variety of industrial materials. It includes commodities such as metals, agricultural raw materials, and energy resources. The

[2] The Raw Materials Index is sourced from the Federal Reserve Bank of St Louis database

index tracks the global benchmark prices for these materials, which are determined based on the largest exporters of each commodity. The components include metals like copper and aluminium, agricultural goods like cotton and rubber, and other critical raw materials that are widely used across industries.

Wool Price versus Wool Supply

An assessment of the EMI to both Australian and global wool production levels since 1990/91 paints a picture of increasing wool price trends in the face of diminishing supply. Figure 8, below, expresses the EMI as an index versus wool production as in index for both Australia and the world.

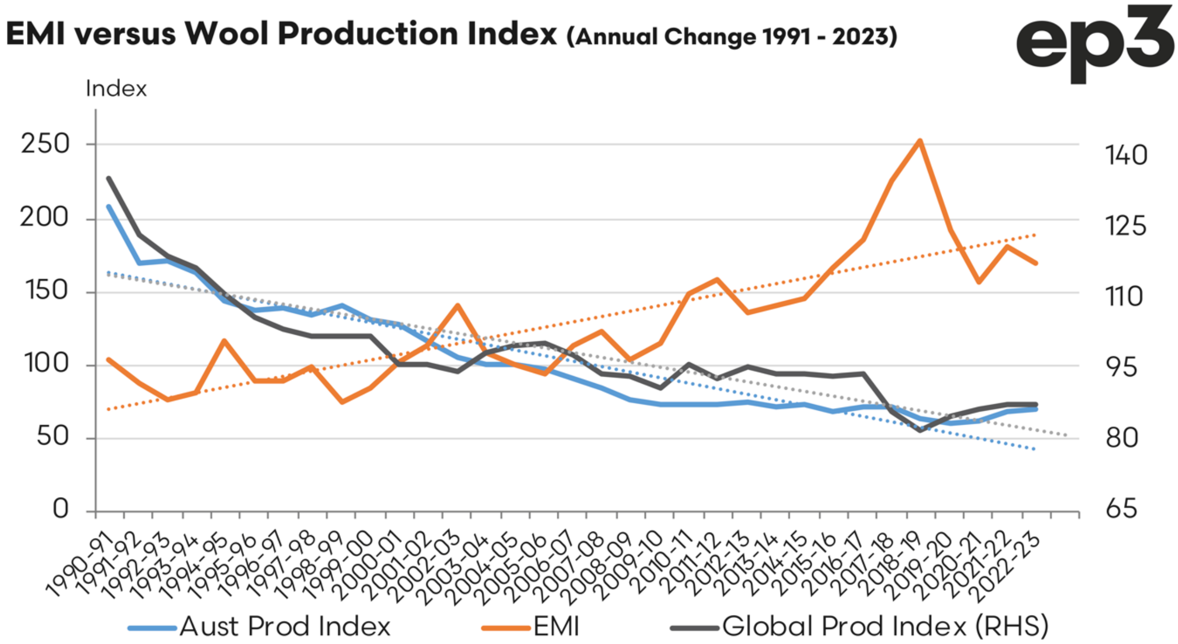

Figure 8 EMI versus Wool Production Index

Overlaid on the diagram is the linear trend for all three indices which highlights an upward trend for the EMI price over the last three decades versus a downward trend for wool production.

Indeed, from 1990 to 2023 the EMI has increased by nearly 65% while Australian wool production has dropped by nearly 67% and the global wool production levels have decreased by around 35%.

In simple economic theory, assuming all other variables a set constant, a drop in supply will lead to an increase in price and this appears to hold true for the EMI in relation to both domestic Australian and global wool production levels.

A comparison of the EMI to Australian wool production as a scatter plot regression over the 1990/91 to 2022/23 period demonstrates a reasonably strong negative correlation coefficient of -0.5047. This negative score indicates an inverse relationship between the two variables, suggesting that as one variable decreases the other one increases. For example, lower Australian wool production is consistent with higher EMI pricing, and vice versa.

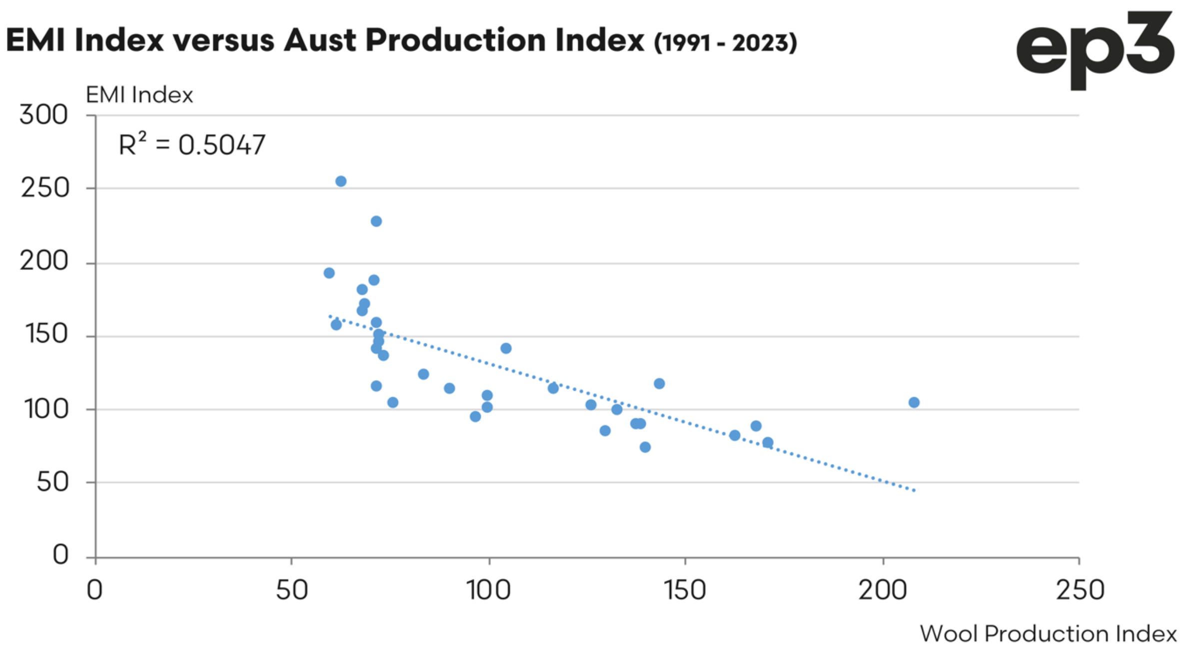

Figure 9 EMI Index versus Australian Wool Production Index

Analysis of the EMI to global wool production levels shows a similar inverse relationship with an R^2 of -0.4647, as outlined in Figure 10, below. This suggests that around half of the variance in the EMI can be explained by the changes to Australian and/or global wool production.

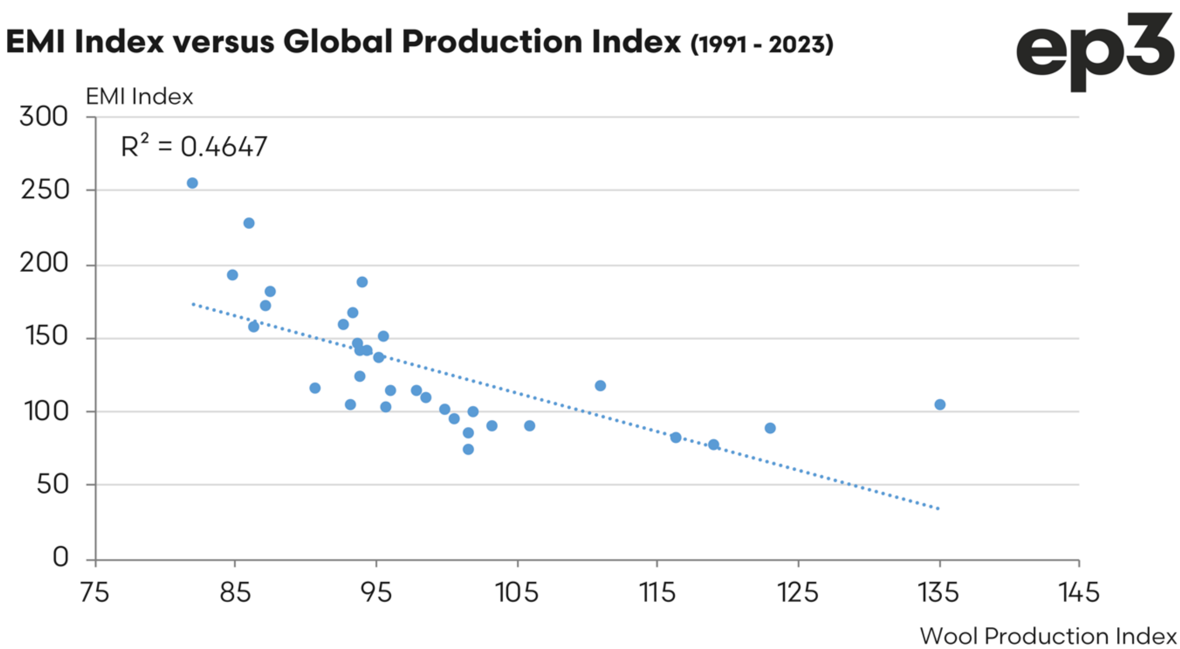

Figure 10 EMI Index versus Global Wool Production Index

Wool Price versus Economic Indicators

As part of the scope for this report the EMI trend was to be compared to a measure of global economic growth. In order to capture key markets relevant to both the processing of raw wool, the manufacture of woollen items and the purchasing of final consumer woollen products we created a Global Growth Indicator in an attempt to capture all of these market segments.

Several lead economic indicators were assessed for inclusion in the Global Growth Index and a selection was made from the following indicators when creating the Global Growth Index:

- Chinese Purchasing Managers Manufacturing Index (PMI)
- German IFO Business Climate Index (IFO)
- US Gross Domestic Product, per capita (GDP)

Chinese Purchasing Managers Manufacturing Index (PMI)

The Chinese Purchasing Managers' Index (PMI) is an economic indicator that measures the activity level of purchasing managers in the manufacturing and service sectors in China. The PMI is used to gauge the health of the country's economy by surveying businesses about factors like new orders, inventory levels, production, supplier deliveries, and employment.

There are two main types of PMI in China, the Manufacturing PMI, which focuses on the manufacturing sector and is a key indicator of industrial activity and the Non-Manufacturing PMI, which Captures the performance of the services and construction sectors. For the purposes of this report the Manufacturing PMI was utilised in the development of the Global Growth Index.

The Chinese PMI is closely watched because it provides early signals about economic growth trends in China, which is one of the world's largest economies. It is particularly important for tracking the performance of key industries and assessing global economic impacts, given China's role in global trade.

German IFO Business Climate Index

The German IFO Business Climate Index is a widely followed economic indicator that measures the business sentiment and confidence among companies in Germany. It is compiled by the IFO Institute for Economic Research and is based on surveys of around 9,000 businesses across various industries, including manufacturing, services, trade, and construction.

This IFO index consists of two main components:

Current Business Conditions Index, which reflects how businesses assess their current situation and the Business Expectations Index, which looks at how businesses expect the economy to perform over the next six months. For the purpose of the development of the Global Growth Index the Current Business Conditions Index was utilised.

The IFO Index is seen as a strong indicator of economic activity in Germany, providing insights into the health of the economy and business sentiment. It is also used as a leading indicator for future growth, both within Germany and for the broader European region.

<u>US Gross Domestic Product, per capita</u>

U.S. GDP per capita measures the economic output of the United States divided by its population. It represents the average economic productivity and standard of living for each individual in the country. By calculating GDP per capita, economists can get a sense of how efficiently a country's economy is growing relative to its population size.

This indicator is useful for comparing economic performance between countries or over time, as it reflects the average income of citizens. When GDP per capita rises, it generally indicates improvements in the standard of living. It is a key measure of economic health and is often used to assess a country's prosperity.

Figure 11, below, demonstrates the annual price change of the EMI compared to the annual change in the Global Growth Index (GGI) from 1991 to 2023 and the trends highlight that improvement in the GGI are often associated with annual increases in the EMI price. Similarly, a decline in the GGI often coincides with a drop in the value of the EMI.

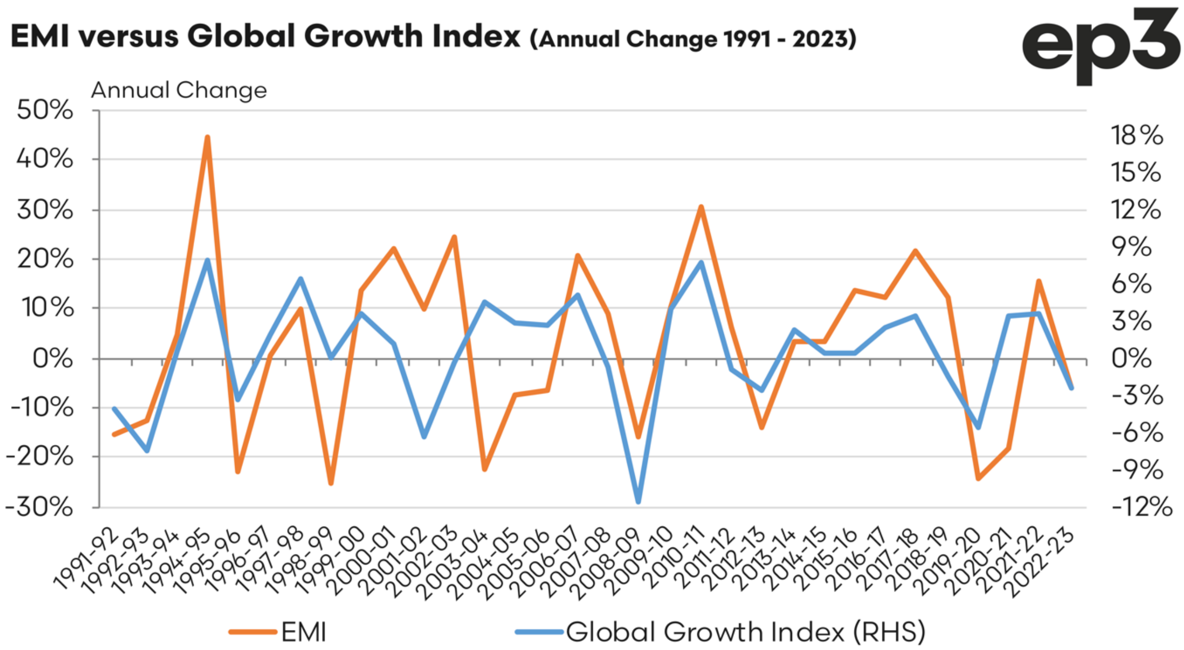

Figure 11 EMI versus Global Growth Index, Annual Change

Analysis of the EMI as an index versus the Global Growth Index using a scatter plot regression highlights a very strong positive correlation with an R^2 of 0.5926 which suggests that nearly 60% of the variance in the EMI each year can be explained by what is happening in the economies of China, Europe and the USA.

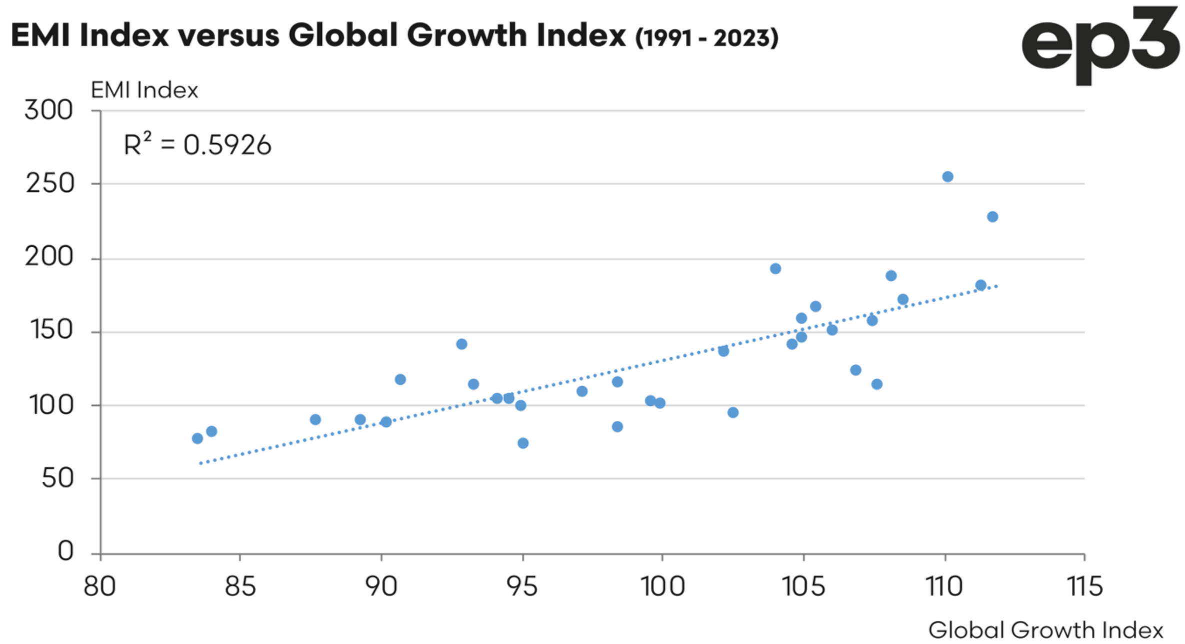

Figure 12 EMI versus Global Growth Index, Annual Change

Assessment of the impact of the woolmarketing spend on the EMI

Undertaking similar analysis as shown earlier in this report and comparing the annual marketing spend to the EMI reveals an interesting trend. Analysis of the annual change in the EMI versus the annual change in the wool marketing spend shows that in some years the directional movements match up, but in several years they are quite divergent.

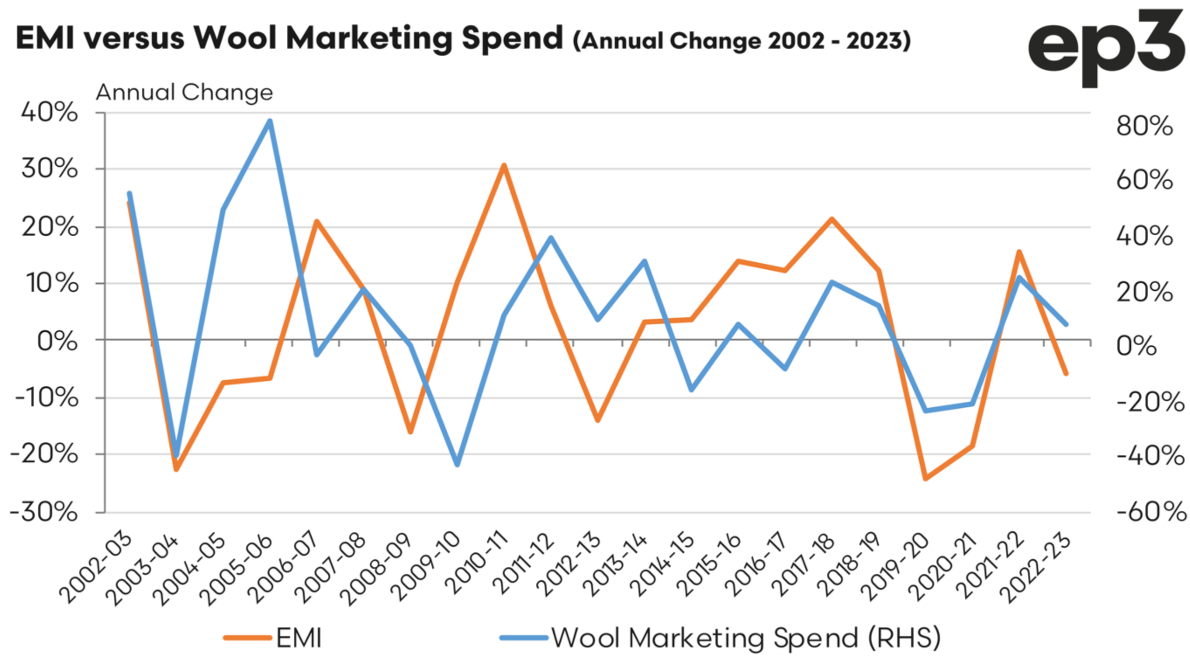

Figure 13 EMI versus Wool Marketing Spend, Annual Change

Indeed, a regression scatter plot of the annual change in the EMI to the marketing spend by shows a relatively poor correlation coefficient of just 0.0771, suggesting that less than 8% of the variance in the EMI each year can be explained by changes to the marketing spend.

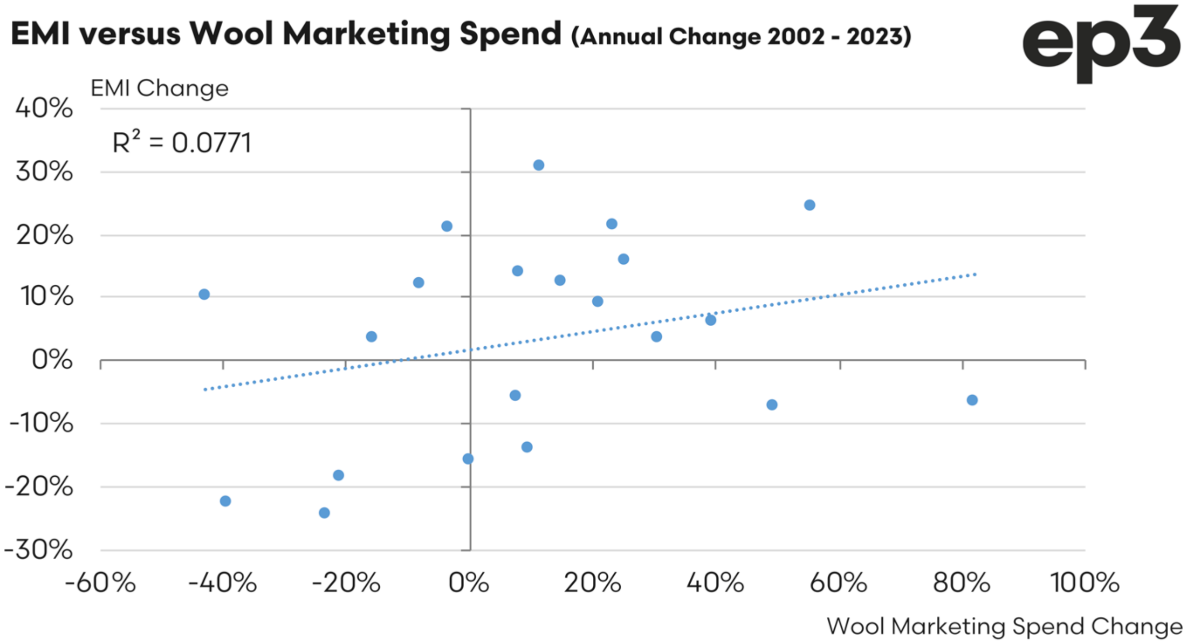

Figure 14 EMI versus Wool Marketing Spend, Annual Change

In order to ensure a thorough assessment of the wool marketing spend and its potential impact upon annual variations to the EMI this report analysed if there were any lagged effects on the EMI. For example, did changes to the wool marketing spend in previous years impact upon the variation to the EMI in later years.

An assessment of the correlation using a one year lag showed an R^2 of just 0.068 and a two year lag showed a correlation of just 0.004, suggesting that the influence of the wool marketing spend on the EMI is very weak, when comparing current year to current year, and tends toward being non-existent over a lagged time frame. These findings are consistent with other academic literature which investigated the key factors that impact upon the price of Australian wool.

In a 2013 study from the University of Sydney[3] it was determined that the price of wool is affected by specific characteristics of each wool lot, such as fibre diameter, strength, breed, and contamination levels. The analysis included all types of wool (superfine to broad) and took into account macroeconomic factors like global economic conditions at the time of sale.

Utilising data from multiple selling seasons, the study identified long-term trends in global wool demand. The results indicated that finer, stronger wool with less contamination commands higher prices, while wool with branding marks, unscourable colour, or skin pieces is discounted.

[3] Gibbon, Candice & Nolan, Elizabeth. (2013). The Australian Wool Industry: A hedonic pricing analysis of the factors affecting price of Australian wool.

Additionally, when moving beyond the individual characteristics of specific wool lots to the broader macroeconomic factors that impact the price trend for wool of all types it was identified that key factors such as global economic growth, substitute product prices, and exchange rates were found to have significant impacts upon Australia's competitiveness in the global wool market. There was nothing in this study that indicated the wool marketing spend was influential on the price trends for Australian wool, although the study did not specifiy if this was a factor that was considered.

Furthermore, a 2024 article published on Sheep Central confirmed that the key drivers of wool prices are the broader macroeconomic conditions, wool supply and the quality characteristics of the wool in question, not the marketing spend.

This publication asserted that 88% of the variation in wool sales could be explained by the prices of non-wool staple fibres. This strong positive correlation suggests that general market conditions for textiles heavily influence wool sales, rather than specific marketing efforts alone.

"Claims about the effectiveness of wool marketing have to account firstly for the big driver of price, macroeconomic conditions, and then the secondary drivers, supply and quality. After the impact of these factors is removed, credit can then start to be allocated to the minor factors such as wool marketing… it appears 88pc of the wool sales value can be accounted for by the general textile market conditions which presumably have nothing to do with wool marketing, leaving the minor effect of 12pc of sales value up for grabs."[4]

This finding leads to a consideration on the scrutiny, or lack thereof, of marketing claims within the wool industry. Bob Richardson, in his critical 2001 paper on the International Wool Secretariat's marketing in the 1980s, argued that agricultural economists did not sufficiently challenge the Australian Wool Corporation (AWC) during the pivotal decades of the 70s and 80s[5]. Richardson suggested that this was partly due to the AWC's role in funding academic research, which may have influenced the degree of critique directed at its marketing strategies.

Reflecting on the views outlined above and the analysis contained within this report, there should be greater emphasises on the importance of regular reassessment of marketing strategies and claims made about its effectiveness in the wool industry. It suggests that without rigorous evaluation, there is a risk of overestimating the effectiveness of wool marketing efforts. This historical perspective underscores the necessity for a balanced and critical approach to analysing marketing investments and their true impact on wool sales and the wool price trend, ensuring accountability and effectiveness in promotional strategies.

[4] https://www.sheepcentral.com/wool-retail-sales-mostly-correlate-with-non-wool-fibre-price/

[5] Richardson, Bob. (2001). The politics and economics of wool marketing, 1950 - 2000

Regression Modelling for the Eastern Market Indicator

This modelling technique investigates how various factors influence the Eastern Market Indicator (EMI), which is a key measure of wool prices in Australia. A regression model is a tool used to understand how different factors (called inputs) influence a result (called the output). In this case, the output is the EMI (Eastern Market Indicator), which shows Australian raw wool prices, and the inputs are things like the exchange rate, wool production levels, and other global factors.

The model works by looking at how changes in these inputs relate to changes in the output. For example, if the exchange rate goes up, what happens to wool prices? The model helps determine if these inputs have a strong or weak effect on the result. It's like trying to figure out what influences a certain outcome - does more of one thing lead to more of something else, less, or no change at all?

The process also checks if the model is doing a good job by using statistical tests, which confirm if the relationships that the model identifies between variables are reliable or if they might just be random. The regression model technique provides an equation that explains in mathematical terms how certain factors have influenced the EMI over time.

The EMI model equation is outlined below:

emi = 162.5 -165.67(cny) + 9.56(raw) - 1.04(aprod) - 2.84(energy) + 19.51(global)

Utilising the EMI model equation above we can replicate an annual range for the EMI according to the model based upon the model input variables for each year and compare how the model performs against the actual annual average EMI from 1991 to 2023.

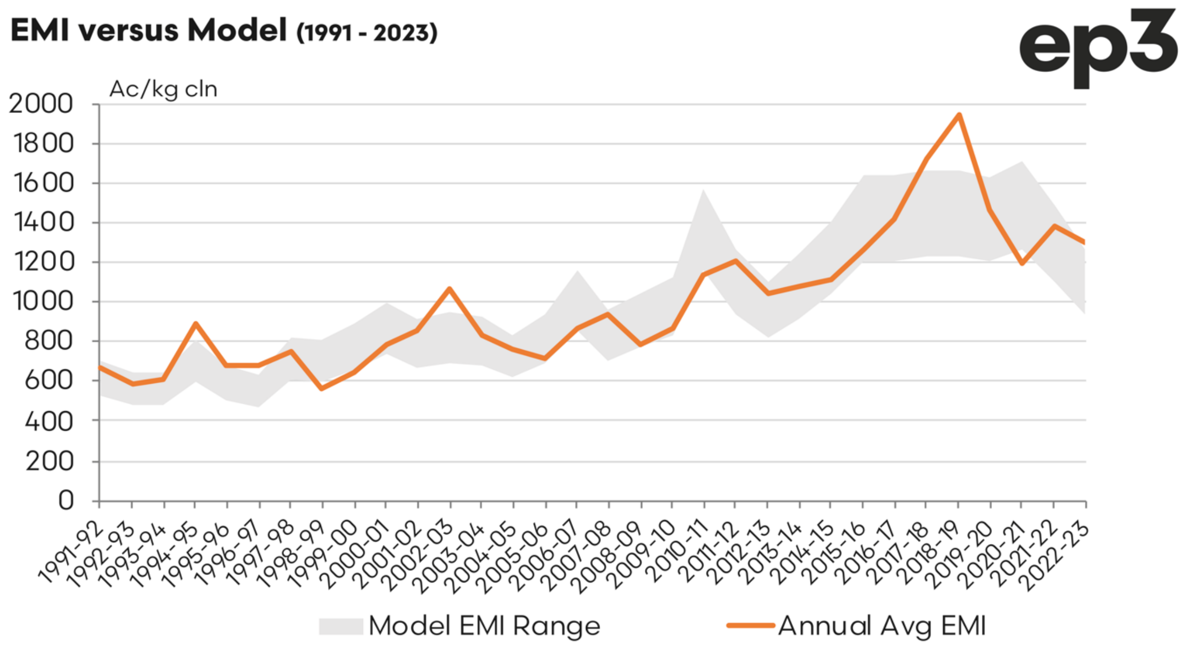

Figure 15 Actual EMI versus EMI Model

The model identified five different inputs to see how they relate to changes in the EMI.

AUD/CNY Exchange Rate (cny): This measures how much one Australian dollar is worth in Chinese yuan. The model shows that as the Australian dollar strengthens against the yuan, the EMI tends to decrease significantly. This suggests that a stronger Australian dollar makes Australian wool more expensive for Chinese buyers, reducing demand and thus lowering the price.

Global Raw Materials Index (raw): This represents the overall price of raw materials worldwide. The model indicates that when global raw material prices increase, the EMI also rises. This indicates that wool prices are subject to the same macroeconomic conditions that influence other raw material prices globally, such as cotton prices.

Australian Wool Production (aprod): This measures how much wool is produced in Australia. The model shows that as wool production increases, the EMI slightly decreases. This is consistent with the basic economic principle that if supply increases, prices are more likely to fall.

Global Energy Index (energy): This index tracks global energy prices. According to the model, higher energy prices tend to decrease the EMI. This is because higher energy costs can increase raw wool processing costs and woollen garment manufacturing costs, affecting wool prices indirectly as wool demand reduces due to tighter margins in the processing sector.

Global Economic Growth Indicator (global): This is a measure of the overall health of the global economy, particularly focused on China, Europe and the USA. The model suggests that as the global economy grows, the EMI increases. A stronger global economy likely boosts demand for wool, driving up prices.

Overall Model Insights

Fit of the Model: The EMI model explains about 74% of the variation in the EMI, which suggests it does a good job of capturing the main factors that influence Australian wool prices.

Significance of Inputs: The AUDCNY exchange rate, global raw materials index, and global energy index have the most significant impact on the EMI. Changes in these factors are closely related to shifts in wool prices.

During the modelling process, we looked at several alternative regression models that added wool marketing spend as an extra factor that may influence the EMI. Although we tried many different versions of the model, using different combinations of inputs and looking at lagged effects, none of the models showed that wool marketing spend had a meaningful impact on the Eastern Market Indicator (EMI).

In fact, adding wool marketing spend often caused problems with the statistical checks that were utilised to confirm the model was fit for purpose. For example, it made the Durbin-

Watson test results worse, or it significantly reduced the model's ability to predict the movement of the EMI.

A more detailed statistical analysis of the EMI model and the inclusion of the wool marketing spend as part of this modelling process is included in the Appendix.

Further Research and Analysis

Due to time and budget constraints the scope of this report, including the allowance for modelling techniques, were limited. However, further work could be undertaken to research and analyse the following areas:

- Additional regression modelling in order to improve upon the EMI model presented in this report.
- Exploration into the research & development spend undertaken to determine if this has a beneficial impact to the Australian wool sector in terms of reduced operating costs for wool producers, on farm efficiency gains and/or productive gains across the broader wool supply chain.

Appendix

Detailed Statistical Analysis of the EMI Regression Model

This regression model examines the relationship between the Eastern Market Indicator (EMI), which represents wool prices in Australia, and five explanatory variables: the AUDCNY exchange rate (cny), Global Raw Materials Index (raw), Global Energy Index (energy), Australian Wool Production (aprod), and a Global Economic Growth Indicator (global).

The diagram below outlines the key statistical characteristics of the model.

	Dependent variable:
	emi
cny	-165.674***
	(49.182)
raw	9.562***
	(2.777)
aprod	-1.039**
	(0.440)
energy	-2.837***
	(0.960)
global	19.507**
	(7.866)
Constant	-162.501
	(981.939)
Observations	31
R2	0.785
Adjusted R2	0.741
Residual Std. Error	173.457 (df = 25)
F Statistic	18.206*** (df = 5; 25)
Note:	*p<0.1; **p<0.05; ***p<0.01

Figure 16 EMI Model Key Statistics

Statistical Summary for the EMI Model

Dependent Variable: EMI (Eastern Market Indicator)
Number of Observations: 31
R-squared (R^2): 0.785
Adjusted R-squared: 0.741
F-statistic: 18.206 ($p < 0.01$)

The R^2 value of 0.785 indicates that approximately 78.5% of the variance in the EMI can be explained by the five independent variables in the model. The adjusted R^2, which accounts for the number of predictors, is slightly lower at 0.741, but still suggests a strong fit. The F-statistic is highly significant ($p < 0.01$), indicating that the model as a whole is statistically significant.

Coefficients and Interpretation

<u>AUDCNY Exchange Rate (cny)</u>

Coefficient: -165.674
Standard Error: 49.182
Significance: $p < 0.01$
The negative coefficient indicates that as the AUDCNY exchange rate increases (i.e., the Australian dollar strengthens against the Chinese yuan), the EMI decreases. Specifically, a one-unit increase in the AUDCNY exchange rate is associated with a decrease of 165.674 units in the EMI. This relationship is statistically significant at the 1% level, suggesting that the exchange rate level is a strong predictor of wool prices.

<u>Global Raw Materials Index (raw)</u>

Coefficient: 9.562
Standard Error: 2.777
Significance: $p < 0.01$
The positive coefficient for the Global Raw Materials Index indicates that an increase in global raw material prices is also associated with an increase in the EMI. A one-point increase in the index is associated with a 9.562-point increase in the EMI. This result is also highly significant, indicating that wool prices are subject to the same macroeconomic conditions that influence other raw material prices globally, such as cotton prices.

<u>Australian Wool Production (aprod)</u>

Coefficient: -1.039
Standard Error: 0.440
Significance: $p < 0.05$
The coefficient for Australian wool production is negative, suggesting that higher wool production is associated with lower wool prices. Specifically, a one-unit increase in production reduces the EMI by 1.039 units. This result is statistically significant at the 5% level, supporting the basic economic hypothesis that increased supply tends to lower prices.

<u>Global Energy Index (energy)</u>

Coefficient: -2.837
Standard Error: 0.960
Significance: $p < 0.01$
The negative coefficient for the Global Energy Index suggests that higher global energy costs are associated with a decrease in the EMI. A one-point increase in the energy index leads to

a 2.837-point decrease in the EMI. This relationship is statistically significant, indicating that energy prices may impact wool prices by influencing wool processing costs and reducing processing margins.

Global Economic Growth Indicator (global)

Coefficient: 19.507
Standard Error: 7.866
Significance: $p < 0.05$
The positive coefficient for the Global Economic Growth Indicator suggests that a stronger global economy leads to higher wool prices. A one-unit increase in the growth indicator is associated with a 19.507-point increase in the EMI. This result is statistically significant at the 5% level, underscoring the importance of global economic conditions in driving demand for both raw wool, processed wool and woollen final products.

Constant

Coefficient: -162.501
Standard Error: 981.939
Significance: Not significant
The constant term is not statistically significant, implying that the baseline level of EMI when all predictors are zero is not meaningful or that the model does not have a meaningful intercept.

Further Diagnostic Tests

Durbin-Watson Test

Durbin-Watson Test: DW = 1.4436 (p-value = 0.009938)

The Durbin-Watson (DW) test is a statistical tool used to detect the presence of autocorrelation in the residuals (errors) from a regression analysis. Autocorrelation occurs when the residuals are not independent of each other, which can violate one of the key assumptions of linear regression and lead to biased or inefficient estimates.

Ideal Range for the Durbin-Watson Statistic

The DW statistic ranges from 0 to 4. A value around 2 indicates no autocorrelation, which is ideal. Values less than 2 suggest positive autocorrelation (residuals are positively correlated). Values greater than 2 indicate negative autocorrelation (residuals are negatively correlated).

Generally, a DW value between 1.5 and 2.5 is considered acceptable, meaning there is little to no autocorrelation in the residuals. This range ensures that the model's assumptions are reasonably met, leading to more reliable and valid results.

In this regression model, the DW statistic is 1.4436, which falls just below the ideal range of 1.5 to 2.5. This suggests a slight presence of positive autocorrelation in the residuals. While this value is marginally outside the desired range, it indicates that the residuals are somewhat correlated with each other, but not excessively so.

Although this slight autocorrelation might not drastically affect the model's overall validity, it does suggest that there could be some patterns in the data that the model hasn't fully captured. This could be addressed by considering additional variables, using a different model specification, or applying techniques to account for autocorrelation if further time/cost was allowed to continue to adjust the model.

<u>Chart-based Diagnostic Tests</u>

The following set of charts highlights four commonly utilised diagnostic plots provided to test the adequacy of the regression model.

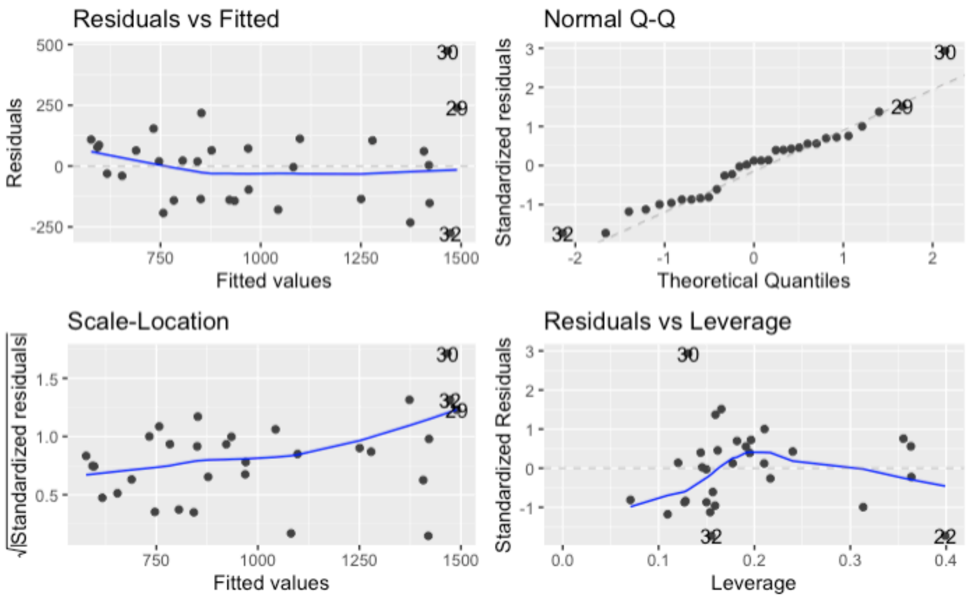

Figure 17 EMI Model Diagnostic Plots

<u>Residuals vs Fitted Values (Top-Left Plot)</u>
This plot checks for non-linearity and homoscedasticity (constant variance) in the model residuals. Ideally, residuals should be randomly scattered around zero.

Observation: There is a slight curve in the residuals, which suggests some very mild non-linearity, but it's not overly severe. For the most part, the residuals remain within a reasonable range, and while some heteroscedasticity (changing spread of residuals) is present, it doesn't appear extreme.

Interpretation: The model may not fully capture the complexity of the relationship between the predictors and the response, but overall, the fit is reasonably good. This level of non-linearity might be acceptable, depending on the specific needs of the analysis.

Although there are slight indications of non-linearity and changing variance in the residuals, they are not severe enough to undermine the overall validity of the model. The model generally fits the data well, and these issues may not need immediate correction unless high precision is required.

Normal Q-Q Plot (Top-Right Plot)
This plot checks whether the residuals follow a normal distribution.

Observation: The points generally follow the 45 degree line, with some deviations at the ends (the tails), indicating that the residuals are mostly normal, except for a few outliers.

Interpretation: While the residuals are not perfectly normal, especially for some larger residuals (observations 29, 30, 32), the deviations aren't too extreme. This indicates the model's assumption of normality is mostly reasonable, with a few outliers that may not significantly affect overall results.

While some deviations from normality are observed in the tails, the majority of residuals follow a normal pattern. The model’s assumption of normality holds up reasonably well, with a few outliers that may not heavily impact the results.

Scale-Location Plot (Bottom-Left Plot)
This plot checks for consistent variance (homoscedasticity) of the residuals.

Observation: There is a slight upward slope in the blue line, suggesting that the variance of the residuals increases slightly with larger fitted values. However, the spread is not drastic, and the pattern remains relatively controlled.

Interpretation: Some minor heteroscedasticity is present, but it's not severe. The model still performs well across a range of fitted values, and this small variance issue may not pose a major concern depending on the final precision needed for the analysis.

Residuals vs Leverage Plot (Bottom-Right Plot)
This plot identifies potentially influential points that may affect the model.

Observation: A few observations (e.g., 30, 29, 32) have larger residuals and moderate leverage, with observation 22 having slightly higher leverage. However, there is no extreme clustering of highly influential points.

Interpretation: While some points stand out as being potentially influential, the overall influence of these points on the model appears to be manageable. These points may require closer examination, but they don't seem to distort the model significantly.

A few points (e.g., 30, 29, 32) might be worth closer inspection, but they do not appear to exert a disproportionate influence on the model’s estimates. Overall, the model is fairly robust despite the presence of these points.

Conclusion for the EMI Regression Model

The model shows a strong overall fit, with significant coefficients for all predictors except the constant. The AUDCNY exchange rate, global raw materials, and energy indices, along with Australian wool production and global economic growth, all play important roles in explaining variations in the EMI.

However, the potential autocorrelation in residuals suggests that there might be some underlying patterns not captured by the current model, which could be improved through further refinement if time and budget was extended.

Furthermore, while the model shows some minor deviations from ideal assumptions, it performs well overall and explains the data effectively. The issues noted—non-linearity, slight heteroscedasticity, and some outliers—are mild and may not require immediate correction depending on the context and the goals of the analysis.

Analysis of the inclusion of the Wool Marketing Spend to the EMI model

An updated regression model, which includes an wool marketing spend (wms) as an additional variable, was assessed as part of this report with several models attempted. Despite numerous variations to the model, differing inputs and lagged analysis there was not any model discovered that indicated the wool marketing spend was statistically significant in influencing the movement of the EMI.

Additionally, the inclusion of the wool marketing spend as an input often invalidated several of the statistical tests applied to the model to test for statistical suitability, such as problematic DW statistic scores or very low model predictive capacity.

Below is an example of the statistical outcomes when the wool marketing spend was added to the model as an additional input variable.

<u>Coefficient for Wool Marketing Spend (wms):</u>

Value: -5.484
Standard Error: 5.496
Significance: The coefficient for wool marketing spend is negative but not statistically significant ($p > 0.1$).

The negative coefficient suggests that increases in wool marketing spend might be associated with a slight decrease in the EMI (Eastern Market Indicator), but since the result is not statistically significant, this relationship cannot be confidently interpreted as meaningful. The large standard error relative to the size of the coefficient indicates a high degree of uncertainty about this relationship.

Interpretation:

The lack of significance for this variable suggests that the wool marketing spend does not have a clear or strong impact on the EMI in the current model. While the marketing spend could potentially influence the EMI through factors like increased demand for wool, the current data do not show strong evidence that this is happening.

Model Fit:

The R^2 value is 0.777, which is quite similar to the previous model without the wool marketing spend, indicating that the overall explanatory power of the model hasn't improved much with the inclusion of this variable.

The Adjusted R^2 value is 0.687, suggesting that after accounting for the number of predictors, the model explains slightly less variability than before and lower than the 74.1% Adjusted R^2 value in the EMI model we adopted for use in this report.

Durbin-Watson Test:

The DW value of 1.1666 shows a stronger indication of autocorrelation, which could indicate that the model still struggles to capture some of the patterns in the data, possibly from missing variables or mis-specified relationships.

Conclusion on wool marketing spend as a model variable

The inclusion of the wool marketing spend does not appear to significantly improve the model, as its coefficient is not statistically significant and the model's overall fit has not greatly improved. It may be worth exploring other ways to measure or represent marketing effects, or reconsidering whether the marketing spend directly influences wool prices (EMI) in a significant manner.