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Modeling Long-term Commodities: the Development of a Simulation Model for the South African Wine Industry within a Partial Equilibrium Framework*

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Abstract

Econometric demand and supply models of agricultural commodities and crops have been around for a long time with extensive research and adaptations being made in the grain and livestock sectors. This much attention has, however, not been afforded to long term commodities. This paper presents a partial equilibrium framework for modeling long term commodities using the South African wine industry as an example. The model structure is presented and two different approaches to closing the model are compared. The usefulness of the model is tested in the form of baseline projections and the analysis of a typical "what if" question. (JEL Classification: D5, L66, Q11)

I. Introduction

The South African wine industry dates back to 1655, became economically significant during and after the Napoleonic wars, and has its roots as a modern industry in the beginning of the 20th century. The first vines were planted shortly after the Dutch settlement in Cape Town; in the early 19th century, vines planted increased from 15 million in 1808–1810 to 32 million in 1823–25 (compared to more than 300 million today), and wine

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made up more than 90 percent of exports from the Cape Colony (Keegan, 1996). By the beginning of the 20th century wine farmers had faced decades of disruptions, principally caused by the surplus production of low quality wine (Vink *et al.*, 2004). This resulted in the establishment of the KWV in 1918, its registration as a company in 1923, and the promulgation of the Wine and Spirits Control Act, No 5 of 1924, which conferred statutory powers on the KWV. These powers lasted until 1997, when the industry was deregulated along with the rest of South African agriculture (Kassier, 1997).

With deregulation came increasing levels of uncertainty as the industry now had to compete in the international arena with a legacy of producing large quantities of cheap wine for the domestic market. Thus, if the industry is to remain viable in the face of global market forces it needs to be more forward thinking and produce more premium cultivars targeted at producing higher quality wine (Vink *et al.*, 2004).

Several models have been built to test the effect of macroeconomic variables on long term commodities (e.g. Wickens and Greenfield, 1973; Askari and Cummings, 1976, 1977; Bond, 1983; Remali and Zulkifli, 1998; Alias and Cheong Tang, 2005). The purpose of this article is to describe the structure of a dynamic, recursive partial equilibrium model of the South African wine industry targeted at assisting the industry with scenario analysis by answering "what if" type questions. Alternative approaches towards model closure are illustrated and discussed and the simulation results generated under the alternative closing mechanisms are compared.

II. Data

All domestic vine, production, consumption, and export data were obtained from the South African Wine Industry Council's information unit, South African Wine Information and Systems (SAWIS), with most data available from 1990. International wine prices and export volumes were obtained from the Compendium of Wine Statistics (Wittwer and Rothfield, 2006). South African macroeconomic variables as well as exchange rates were obtained from the South African Reserve Bank and Statistics South Africa websites.

III. The Basic Model

The methodology developed by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri has proven convenient for conducting scenario planning and policy analysis (Meyer and Kirsten, 2005) and underpins the approach used for modeling the South African wine sector. In this article, the FAPRI methodology is adapted to suit the nature of a long-term commodity such as wine. Since the principle objective of this research is to develop a well-behaved econometric model that is able to capture the salient features of the wine industry, alternative estimation and validation procedures are followed in some cases to find estimates that provide an accurate prediction of reality. The limited number of observations

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makes it difficult in some instances to estimate reliable parameters using econometric techniques. Moreover, the time period covered by the data is characterized by major shifts in the industry including the first democratic election in South Africa in 1994 and deregulation in 1997. In some instances including a shift variable was sufficient to capture the impact of change, but other times the dynamics in the market changed to such an extent that estimating an equation over the entire time frame yielded results contradictory to basic economic theory. In such instances, synthetic parameters are imposed to ensure reasonable model behavior.

The basic structure is presented in three main sections, namely the supply block (A), the demand block (B) and the pricing and closing block (C). Two distinct approaches that can be used to close the model are illustrated in section C below. In the first approach simple price linkage equations are estimated and stock levels are used to equilibrate demand and supply. In this approach one can argue that prices are estimated by an equation within the system and therefore endogenous but in a certain sense also "pre-determined" because they are not equilibrated by demand and supply. In the second approach, however, stock levels are estimated and **endogenous** prices are generated by using a price-equilibrator approach to equilibrate demand and supply. The theoretical equations are presented and explained in the section below[1]. This model captures ten main varietals of which some are produced in eight regions in South Africa. This implies that the supply block alone consists of 65 estimated equations, of which some equations represent small regions and therefore only a small share of the total plantings.

A. *The Wine Grape Supply Block*

The South African wine industry can be divided into eight main producing regions, each better suited to certain varietals. Vine bearing numbers change over time due to new plantings and the removal of older less productive vines. The number of vines per hectare can also vary for a number of different reasons such as location, slope, varietals and trellising practice. It is for this reason that the total number of vines rather than hectares planted to vines is modeled. The model makes provision for the ten main varietals produced in South Africa as well as for the eight producing regions. The number of varieties modeled individually is based on their percentage contribution to the total number of vines within the region, with a minimum contribution of 1%. Varietals not modeled individually are included in "other white" and "other red". Table 1 reports the varietals modeled individually per region.

When modeling the supply of perennial crops, there are a number of options available to the researcher: the first is to model "new plantings" which after four years are added to total number of bearing vines, while uprooted vines are simply subtracted. The second option is to model "change in vine numbers" per year and then adding this, with the four year lag if positive, to the total number of bearing vines. This option would eliminate the inclusion

[1] Detailed equations with the various coefficients and elasticities can be obtained from the authors on request[0].

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Table 1
Varietals Modeled Individually per Region

Varietal	*Region*
Cabernet Sauvignon	Malmesbury, Paarl, Robertson, Stellenbosch, Worcester
Chardonnay	Little Karoo, Malmesbury, Olifants River, Paarl, Robertson, Stellenbosch, Worcester
Chenin Blanc	Little Karoo, Malmesbury, Olifants River, Orange River, Paarl, Robertson, Stellenbosch, Worcester
Cinsaut Noir	Malmesbury, Paarl, Stellenbosch, Worcester
Colombar[a]	Little Karoo, Malmesbury, Olifants River, Orange River, Paarl, Robertson, Worcester
Merlot	Malmesbury, Olifants River, Paarl, Stellenbosch, Worcester
Pinotage	Malmesbury, Olifants River, Paarl, Stellenbosch, Worcester
Sauvignon Blanc	Malmesbury, Olifants River, Paarl, Robertson, Stellenbosch, Worcester
Shiraz	Malmesbury, Olifants River, Paarl, Robertson, Stellenbosch, Worcester
Sultana	Orange River
Other Red	Little Karoo, Malmesbury, Olifants River, Orange River, Paarl, Robertson, Stellenbosch, Worcester
Other White	Little Karoo, Malmesbury, Olifants River, Orange River, Paarl, Robertson, Stellenbosch, Worcester

[a] *South African name for French Colombard*

of replacement vines. The third and possibly simpler option is to model "vine bearing numbers" directly. This option would reduce the number of equations required and by lagging the grape price term by four years, eliminate the need to adjust between vine numbers and bearing vines. Given the number of regions and varietals included in the model, the third option was preferred. A lag of five years proved to better fit the data, with the exception of Orange River. A possible reason for this is plantings are often postponed one term as producers need to order the appropriate plant material one year in advance. The usefulness of following this approach will be illustrated in section IV of this paper, where the model is used to simulate the impact of a shock in the exchange rate.

To allow for cross price elasticities as well as inter-varietal elasticities, supply was modeled in two steps, in order to conserve degrees of freedom given the large number of varietals. The two steps were based on the assumption that the farmer has to make two main decisions that impact on wine grape supply. The first decision is whether to plant vines or other alternative crops suitable to the particular region. Following this, the farmer still needs to decide which varietals to plant.

All supply equations are driven by a type of real expected gross return variable. Real expected gross return ($EGRT_{i,t}$) is calculated as the average yield per variety multiplied by the expected price per variety, deflated by the Gross Domestic Product deflator ($GDPD_t$).

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Within each region, total vine numbers ($TVP_{r,t}$) are estimated as a function of the previous year's total vine numbers and the weighted sum of all the varietals' expected real gross return ($WEGRT_{r,i,t}$) lagged five years. A shift variable was included in four of the eight regional supply equations to capture the impact of deregulation. Equation 1 shows the typical format of a regional supply equation, with r, i and t denoting region, variety and time respectively.

$$TVP_{r,t} = f(TVP_{r,t-1}; sum(WEGRT_{r,i,t-5},)) \tag{1}$$

Vine numbers for the individual varietals are expressed as the share of the total vines in the region ($VPSH_{r,i,t}$), and are estimated as a function of the real gross expected return to the particular variety ($EGRT_{r,i,t-5}$) divided by the weighted sum of the expected real gross returns ($WEGRT_{r,i,t-5}$) to all the other varietals. This is applied to the varietals specified in each region. The advantage is that it allows for the determination of cross price elasticities among the different varietals.

$$VPSH_{r,i,t} = f\left(VPSH_{r,i,t-1}; \frac{EGRT_{i,t-5}}{sum(WEGRT_{r,i,t-5})} \right) \tag{2}$$

Vine numbers per variety per region ($TVP_{r,i,t}$) can now be calculated by multiplying the total vine numbers ($TVP_{r,t}$ – estimated in equation 1) by the share for the particular variety for that particular region ($VPSH_{r,i,t}$ – estimated in equation 2).

$$TVP_{r,i,t} = TVP_{r,t} \times VPSH_{r,i,t} \tag{3}$$

Total vine numbers per variety are calculated by adding the vine numbers of the various regions. Trellising practices, slope, wind and rain, and cultivar all affect yield ($YIELD_{i,t}$). Because the specific micro climate on each farm significantly affects yields, a three year moving average yield was used to determine total grape production per variety ($PRODGR_{i,t}$).

$$PRODGR_{i,t} = TVP_{i,t} \times YIELD_{i,t} \tag{4}$$

Specification of the transition from wine grapes to wine is not simple, as there is no average extraction rate or conversion rate from grapes to wine per variety. This, combined with the fact that there is no data that specify which grapes or variety of grapes was used in the production of wine (referred to as 'good wine'[2]) as opposed to other products such as rebate wine[3], distillates, or grape juice concentrate, required a drastic simplification in the estimation of wine production. The production of wine ($GWPROD_t$) is therefore estimated as a function of total red wine grapes produced ($TOTREDG_t$), total white wine grapes produced ($TOTWHG_t$). The production of rebate wine ($RBPROD_t$) is estimated as a function

[2] 'Good wine' is a broad term used in the South African industry to describe wine intended for drinking purposes, i.e. natural, fortified and sparkling wine (Kassier, 1997).

[3] In the South African industry, wine that is destined for the production of brandy is exempt from excise duties, hence rebate wine.

of the previous year's rebate wine production and the real price of rebate wine ($RREBPR_t$). On average, the total litres of fluid (wine, distillates, rebate wine and grape juice concentrate) produced from one ton of wine grapes is 774 litres. Thus distillates and grape juice concentrate production is calculated by multiplying the total wine grape crop by 0.774 and subtracting the estimated wine and rebate wine production.

$$GWPROD_t = f(TOTREDG_t; TOTWHG_t) \tag{5}$$

$$RBPROD_t = f(RBPROD_{t-1}; RREBPR_t) \tag{6}$$

The imports of wine and fruit concentrate is modelled as a function of the real good wine price ($RGWPR_t$) and the sum of distillates ($DISPROD_t$) and grape juice concentrate ($NAPROD_t$).

$$IMP_t = f(RGWPR_t; DISPROD_t + NAPROD_t) \tag{7}$$

B. *The Wine Demand Block*

The demand for wine is broken down into two main segments, namely domestic demand and export demand. While the demand curve of a product relative to its own price is conventionally downward sloping, wine economists might argue that higher prices can actually increase demand as a consumer's perception of wine quality is positively related to its price. Larivière *et al.*, (2000) compiled a table of own price elasticities for wine indicating that the own price elasticity varies from –1.35 to 0.16. For the purpose of this model however, no quality distinction was made between different wines due to a lack of relevant data. For this reason, wine is considered a commodity having specific consistent quality attributes.

As stated previously, the demand for South African wine can be divided into domestic ($DOMCON_t$) and export demand. Domestic demand was estimated, in terms of per capita consumption ($PCWINECON_t$), as a function of the real wine price ($RGWPR_t$) and real per capita GDP ($RPCGDP_t$) which serves as a proxy for the income level of the population.

$$PCWINECON_t = f(RGWPR_t; RPCGDP_t) \tag{8}$$

The average own price elasticity of demand for wine in South Africa is estimated at –0.113, which implies that if the good wine price increase by 10%, the local consumption of good wine decreases by 1.13%.

Export demand was disaggregated into red and white wine exports per country for the United Kingdom, the Netherlands, Germany, Scandinavia, Australasia, Canada, Belgium, France, the USA, and other countries. Exports were disaggregated into white and red wine exports because the elasticities proved to be statistically different. Export demand per country per red and white wine ($EXP_{c,k,t}$) was estimated as a function of lagged exports

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as consumers acquire a taste for South African wines, the Rand/US Dollar ($RUSD_t$) or Rand/Euro ($REURO_t$) exchange rate depending on the importing country, the real good wine price, and a weighted average "new world" wine price. The weighted average "new world" wine price ($NEWWP_t$) was calculated using the wine export prices of Spain, Australia, New Zealand, USA, Chile, and Argentina together with their export volumes as weights. For red wine the own price elasticities of export demand ranges between −0.25 and −0.45 and for white wine it ranges from −0.25 to −0.38.

$$EXP_{c,k,t} = f(EXP_{c,k,t-1}; RUSD_t; REURO_t; RGWPR_t; NEWWP_t) \quad (9)$$

C. *The Pricing and Closing Block*

Reaching equilibrium in a partial equilibrium framework requires that total demand needs to equal total supply. This process is referred to as model closure. Equilibrium pricing conditions dictate model closure. With relatively homogenous commodities like grains, one basically can follow two main categories of model closure. Either prices are modeled endogenously in the system when the local market solves under autarky, or when the nation is importing or exporting prices can be pre-determined by parity prices (Meyer *et al.*, 2006). In the case of wine, equilibrium pricing conditions are more complicated for several reasons. First, wine is not a homogenous commodity and secondly, prices may not be determined by pure supply and demand forces due to the structure of the wine industry. The South African industry is characterized by many small sellers of bulk wine and only a few wholesalers buying the bulk wine transforming it into the final product. Therefore two alternative closing mechanisms are investigated and compared. The first approach is ensuring demand equals supply by allowing stocks to adjust. In other words, stock change is calculated as the difference between demand and supply, while demand and supply interacts only via price equations (hereafter referred to as Closure 1). Under Closure 1, prices are exogenous to the system of equations. The second approach (hereafter referred to as Closure 2) is that of a price equilibrator simulating the price of the good wine ($RGWPR_t$) and stocks are estimated in the form of an equation. Under Closure 2, prices are endogenous to the system of equations.

Closure 1: The average real good wine price is estimated as a function of the previous year's price, the ending stock (ES_{t-1}) to demand ratio lagged one year, the Rand/Euro exchange rate and the production of good wine for the current season. Lagged variables are used as prices are often negotiated around November before the onset of the season.

$$RGWPR_t = f(RGWPR_{t-1}; \frac{ES_{t-1}}{DOMCON_{t-1} + TOTWINEEXP_{t-1}}; REURO_{t-1}; GWPROD_t) \quad (10)$$

Having created links between supply and demand using a price equation, the final step is an equilibrating identity which is derived from basic economic theory, namely that supply should equal demand. The equilibrating equation or closing identity can take many forms depending on how one chooses to close the system. This system was closed using

"change in stock" approach. The change in stock levels is an identity and is equal to wine production plus wine imports, less exports and domestic consumption.

$$STCH_t = GWPROD_t + IMP_t - EXP_t - DOMCON_t \tag{11}$$

Closure 2: With the price equilibrator approach the real good wine price is simulated endogenously in the model by finding the equilibrium price where demand for good wine equals supply of good wine.

Theoretically the price equilibrator can be presented as follows:

Beginning real good wine price	1. $= RGWPR_{t-1}$
Total demand	2. $= TOTWINEEXP_t + DOMCON_t + STCH_t$
Total supply	3. $= GWPROD_t + IMP_t$
Export demand	4. = 2–3
New real good wine price	5. $= RGWPR_t$

Opposed to Closure 1 where the change in stock is calculated in the form of an equilibrating identity, the change in stock ($STCH_t$) under Closure 2 is estimated as a function of good wine production plus net imports and the real good wine price. The expected sign of the first variable is positive whereas the relationship between stocks and price is negative.

$$STCH_t = f(GWPROD_t + IMP_t - EXP_t; RGWPR_t) \tag{12}$$

The prices of rebate and distilling wine cannot be simulated using a price equilibrator as no time series data is available on final demand for these products. For this reason, in both closures, the rebate price ($RREBPR_t$) is a function of the good wine price and the distillate and grape juice price ($RDISPR_t$) is again linked to the rebate price.

$$RREBPR_t = f(RREBPR_{t-1}; RGWPR_t) \tag{13}$$

$$RDISPR_t = f(RDISPR_{t-1}; RREBP_t; DISPROD_t + NAPROD_t) \tag{14}$$

Finally, an explanation is needed on the link between the price of wine (including good wine, rebate wine and distilling wine) and the grape prices. The wine varietals included individually in this framework can be divided into two broad categories: noble and non-noble varietals. The distinction is made because noble varietals are more likely to be made into good wine as opposed to rebate wine, distillates or grape juice concentrate. For this reason, the real grape price of noble varietals ($RNGPR_{i,t}$) is estimated as a function of the real wine price and total production of the variety in question. These varietals include Merlot, Chardonnay and Sauvignon Blanc. Though the other red varieties are also considered noble varietals, the estimated equations proved it best to link the prices of these varieties to that of Merlot ($RMERP_t$) as opposed to the good wine price. Non-noble varietals' real grape price ($RNNGPR_{i,t}$) is estimated as a function of the total production of the particular variety and either the price of rebate wine or distillates. These price equations thus show

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how the price of the value-added secondary commodity "wine" is imposed or transferred to the primary commodity "grapes". More importantly, the grape prices simulated by these equations also drive total vine numbers and therefore total supply of grapes and consequently wine, as the weighted expected real gross return variable in equation 1 is based on the varietal's real grape prices. In other words, these price equations are the link allowing the supply of grapes and the demand of wine to interact over the longer term.

Price equation for Merlot, Chardonnay and Sauvignon Blanc:

$$RNGPR_{i,t} = f(RGWPR_t; PRODGER_{i,t}) \tag{8.1}$$

Price equation for other red varietals;

$$RNGPR_{i,t} = f(RMEP_t; PRODGR_{i,t}) \tag{8.2}$$

Price equation for other white varietals:

$$RNNGPR_{i,t} = f(PRODGR_{i,t}; RREBPR_t; RDISPR_t) \tag{9}$$

Table 2 is a summary of the variables in the model, distinguishing between endogenous and exogenous.

IV. South African Wine Industry Outlook

The partial equilibrium framework allows for the development of representative outlooks, based on assumptions about exogenous variables. To enable the analysis of various external shocks on an industry, one needs a benchmark or starting point from where the deviations can be measured. This benchmark is referred to as a "Baseline". The baseline simulations illustrate the possible outcomes given a certain set of assumptions. The outlook for selected macroeconomic variables was obtained from Global Insight (2007). Global Insight provides economical, political and financial coverage and forecasts for over 200 countries. Table 3 reports the assumptions made about various macroeconomic variables included in the framework.

Based on the above assumptions and actual data up to 2007, the simulation model generates the baseline for the wine industry over the period 2008 to 2015. The baseline for selected production and consumption variables is presented in Table 4 and Figures 1 and 2.

Under closure 1 the real good wine price increases up to 2010, where after it declines for three consecutive years before recovering to some extent reaching R2.37/liter in 2015. Under closure 2 the real good wine price increases steadily over the next eight years reaching R2.26/liter in 2015. The real good wine price is consistently higher under closure 1 compared to closure 2. One of the drivers in this relatively higher price is the inclusion of the exchange rate in price equation. The relatively higher prices of closure 1 result in lower consumption levels. Due to the inelastic nature of supply response of perennial crops,

Table 2
Exogenous and Endogenous Variables

Endogenous	*Exogenous*
Total vine numbers ($TVP_{r,t}$)	Rand-US dollar exchange rage ($RUSD_t$)
Total vine numbers per variety per region ($TVP_{r,i,t}$)	Rand-Euro exchange rate ($REURO_t$)
Expected gross real return ($EGRT_{i,t}$)	Gross domestic product of South Africa (GDP_t)
Weighted expected gross real return ($WEGRT_{r,i,t}$)	GDP deflator ($GDPD_t$)
Varietal share of total vine numbers per region ($VPSH_{r,i,t}$)	Population of South Africa (POP_t)
Grape production per variety ($PRODGR_{i,t}$)	Real per capita GDP ($RPCGDP_t$)
Total production of red grapes ($TOTREDG_t$)	Yield per variety ($YIELD_{i,t}$)
Total production of white grapes ($TOTWHG_t$)	Weighted avg new world wine price ($NEWWP_t$)
Total good wine production ($GWPROD_t$)	
Total rebate wine production ($RBPROD_t$)	
Total distilling wine production ($DISPROD_t$)	
Total non-alcoholic production ($NAPROD_t$)	
Domestic consumption ($DOMCON_t$)	
Per capita consumption ($PCWINECON_t$)	
Total wine exports ($TOTWINEEXP_t$)	
Wine exports per country ($EXP_{c,k,t}$)	
Real grape price per noble varietal ($RNGRPR_{i,t}$)	
Real grape price per non-noble varietal ($RNNGRPR_{i,t}$)	
Real merlot grape price ($RMEP_t$)	
Real good wine price ($RGWPR_t$)	
Real rebate wine price ($RREBPR_t$)	
Real distilling wine price ($RDISPR_t$)	
Ending stock (ES_t)	
Change in stock ($STCH_t$)	
Imports (IMP_t)	

Table 3
Macroeconomic Assumptions

Macro Variables	*2008**	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Real GDP/Capita R1000 (*RPCGDP*)	18.0	18.6	19.3	20.3	21.4	22.7	24.0	25.5
GDP deflator (% change) (*GDPD*)	9.1	5.7	5.5	5.0	4.8	4.6	4.6	4.5
SA cents/€(*REURO*)	1159	1199	1222	1248	1277	1325	1393	1393
SA cents/US $ (*RUSD*)	767	814	858	900	939	977	1015	1057
Total population of SA in millions (*POP*)	47.6	47.8	48.0	48.1	48.3	48.5	48.7	49.0

Source: Global Insight, 2007, *Adjustments were made to the 2008 projections of Global Insight

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Table 4
Simulation Results: Closure 1 vs. Closure 2

		2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Real Good Wine Price	Closure 1	2.09	2.12	2.40	2.43	2.36	2.31	2.28	2.29	2.37
(R/liter)	Closure 2	2.09	1.97	1.99	1.97	2.01	2.09	2.13	2.18	2.26
Good Wine Stock:	Closure 1	0.582	0.580	0.609	0.657	0.685	0.700	0.713	0.717	0.721
production ratio	Closure 2	0.582	0.564	0.550	0.543	0.522	0.503	0.490	0.472	0.450
Good wine production	Closure 1	730	721	750	758	758	767	770	773	780
(mill. liters)	Closure 2	730	721	750	758	758	767	769	770	771
Tot. wine exports	Closure 1	313	355	359	367	381	392	402	414	426
(million liters)	Closure 2	313	360	371	384	398	406	412	422	433
Domestic consumption	Closure 1	378	362	349	348	351	351	349	346	342
(million liters)	Closure 2	378	365	357	357	358	356	352	348	344

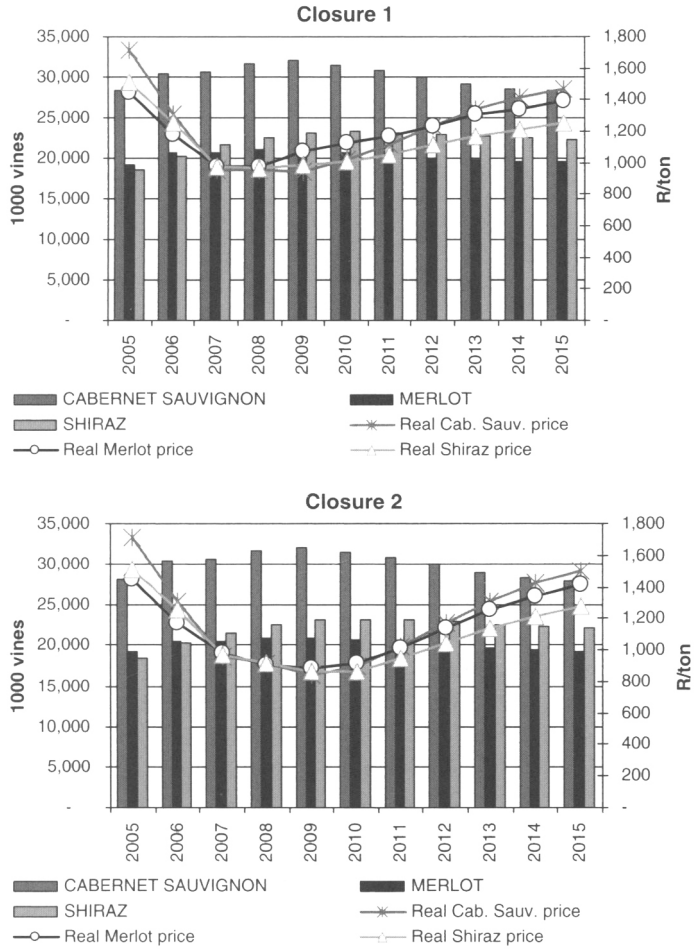
the impact of the higher prices is only evident in production from 2012 onwards (visible in Table 2 from only 2013 due to rounding). The projected production under closure 1 exceeds production under closure 2 by 9 million liters in 2015. The higher production and lower consumption results in higher ending stock to good wine production ratio.

During the nineties there has been a strong tendency to replace old vineyards with red varieties, a phenomenon that was not unique to South Africa. The increased plantings, and thus increased production, of red wine grapes has resulted in a relative surplus not only domestically but also internationally, which has resulted in a decrease in real red grape prices (see Figure 1). Producers responded to the falling prices by shifting new plantings to white varieties, resulting in a declined area under red wine grapes in 2006 and 2007. Figure 1 shows the corresponding decline in vines in production of Cabernet Sauvignon grapes from 2010. The number of vines in production is stabilizing in 2015 where after it is expected to turn upwards following the increasing trend in prices over the baseline period. Merlot and Shiraz grape vines in production follow a similar trend. For both closures, the prices follow a similar trend as the real good wine price, but the grape supply of the relevant varietal also plays a role. Supply of red grapes is expected to be down from the 2007 crop, supporting the prices of red wine grapes. Prices are projected to flatten off from 2015 onwards as vines in production and thereby supply stabilizes.

The replacement of old vineyards with red varieties during the 1990s and the resulting oversupply of red wine was accompanied by a relative shortage in the production of white wine, increasing prices of white grape varieties during the first half of this decade. Increasing prices of white grape varieties and declining prices of red grape varieties during the early 2000s led to new plantings shifting to white varieties. Supply of white grapes increased as vines came into full production approximately 4 years later. The increase in supply, lower export growth (the volume of exports actually declined in 2006) and the

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Figure 1
Outlook of Selected Red Vines in Production and Red Wine Grape Prices

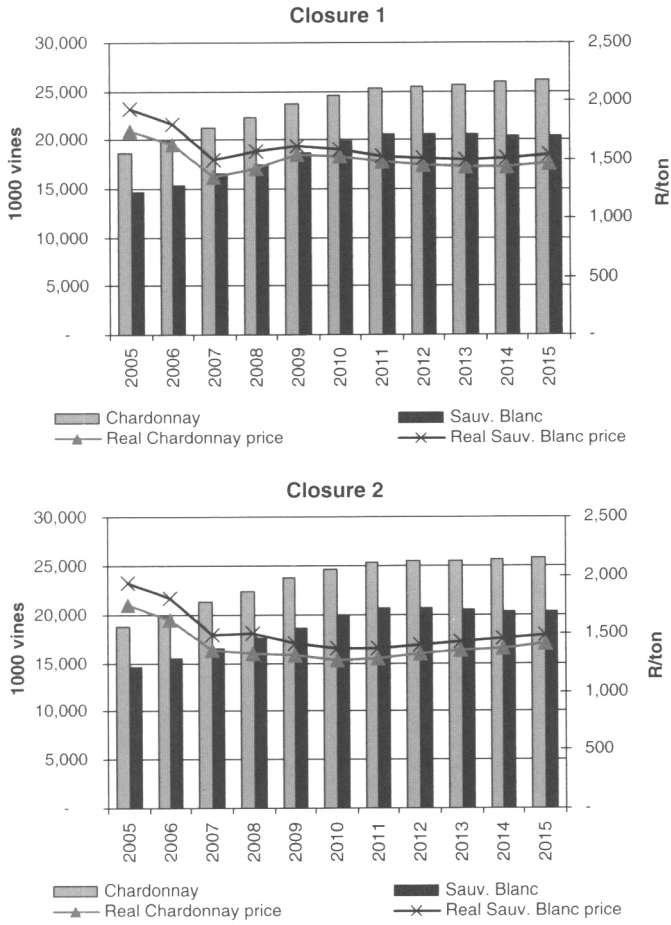


stagnant domestic market, resulted in the prices of white grape varieties coming under pressure in 2004. Since then the prices of white grapes followed a downward trend. Under closure 1 the real good wine price is projected to support the prices of white grapes in 2008 despite increasing supply (see Figure 2). However, over the period 2010 to 2013 the higher supply is projected to depress white grape prices. Under closure 2 the price of Chardonnay and Sauvignon Blanc grapes is projected to decline marginally up to 2010, where after it sets on a slightly upward trend. Under both closures Chardonnay vines in full production remains on an upward trend, though at a much lower rate than the past few years.

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Figure 2
Outlook of Selected White Vines in Production and White Wine Grape Prices



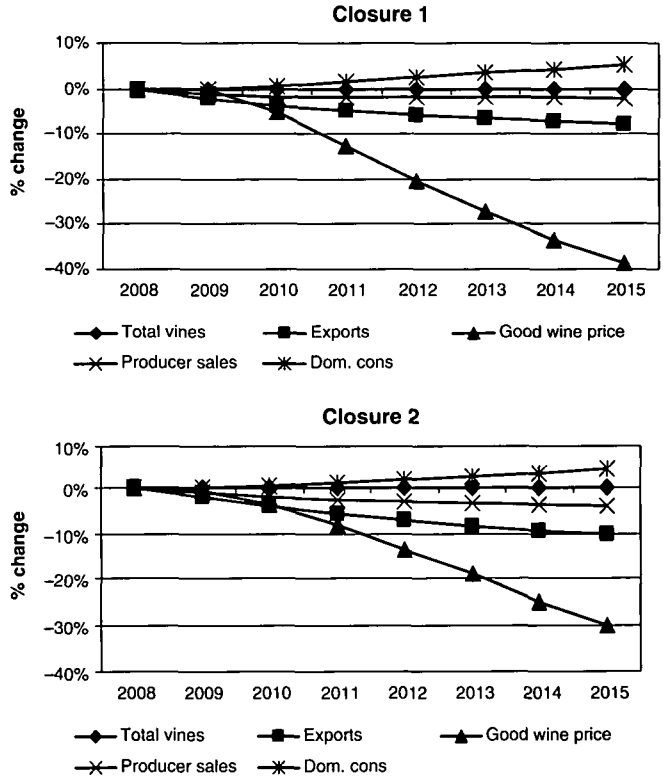
V. Examples of Model Applications

As stated previously, the baseline can be used as a benchmark to understand the impact of external shocks on the industry. These shocks can be calculated as absolute and percentage deviations from the baseline. The wine industry is to a large extent export driven; hence the exchange rate is one of the critical external drivers in the model. The industry is aware of the risks embedded in a highly volatile exchange rate and is constantly raising questions regarding its impact. In this section, therefore, the possible impact of an appreciation in the exchange rate (relative to the baseline) over time is investigated. For illustrative purposes,

it is assumed that the exchange rate stays fixed at the baseline projection levels of 2008 instead of depreciating over time. In other words, the exchange rate trades at R7.67/US $ and fluctuates between R10.41/€ and R11.60/€ over the baseline period. Figures 3 to 5 present the deviations from the baseline as percentage changes.

Figure 3 presents a summary of the supply, demand, exports and price components in the model for the different closure rules. The simulation results indicate that a strengthening in the exchange rate drives down prices because earnings in export markets decrease. As expected, the impact on the good wine price under closure 1 is larger. However, surprisingly the decline in exports under closure 1 is less than 10%, whereas it is more than 10% under the closure 2. The increase in domestic demand under closure 1 exceeds that of closure 2. This can be explained by the relatively larger price impact of closure 1. The impact on producer sales (including domestic and export sales) of –2.2% under closure 1 is smaller than the –4.3% under closure 2.

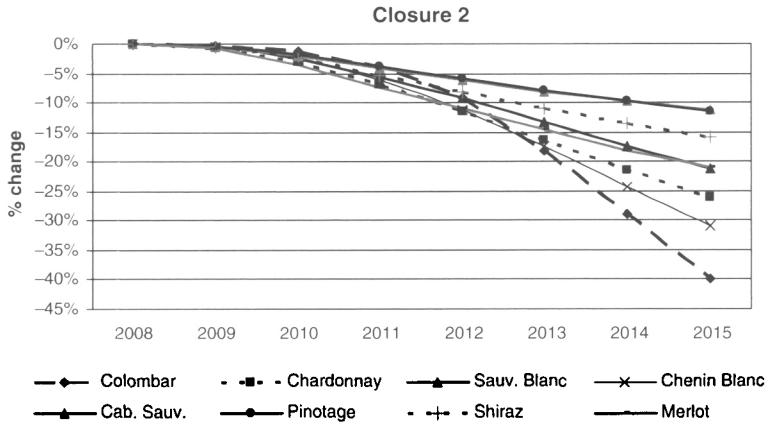
Figure 3
Wine Industry Overview
Percentage Change from Baseline



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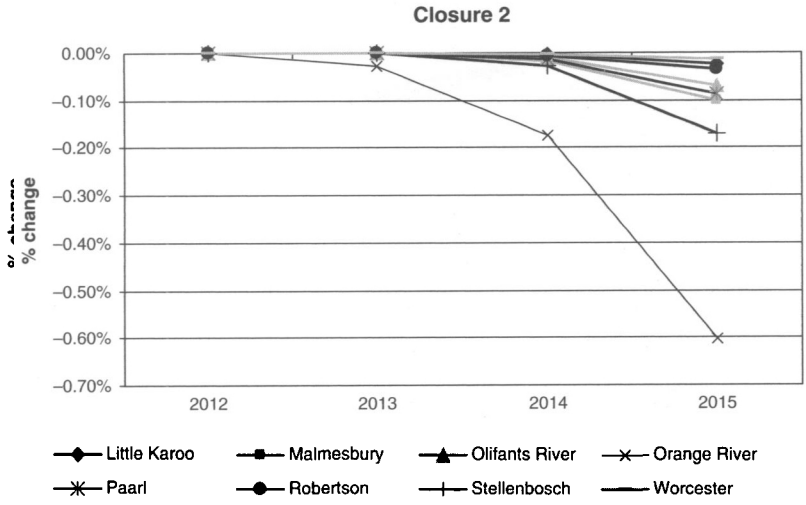
Figure 4
Grape Prices
Percentage Change from Baseline



Only the results of closure 2 are shown for the remainder of this section, because the relative impacts are fairly similar as only the magnitudes differ resulting from the different impact on the real good wine price. The impact of the lower good wine price relative to the baseline on grape prices are mixed as illustrated in Figure 4. Initially, the greatest impact is on Merlot, Shiraz, Chardonnay and Sauvignon Blanc grapes, but over time as plantings adjusts the greatest impact is on Chenin Blanc and Colombar. A number of factors should be taken into account attempting to explain the price behavior. These include: (i) the age structure of the vineyards; (ii) the longer lifespan of red vines compared to white vines; (iii) the aging of red wine that can serve as a buffer against slowdown in demand, whereas white varieties should be sold preferably within one or two years; and (iv) the market segment (good wine, rebate, distillate or fruit juice concentrate) for which grapes are destined. For example, Colombar and Chenin Blanc are the main varietals used as distilled wine. The distillate component of wine production serves as a sort of excess removal of wine in the South African industry. Hence, an oversupply of wine is expected to impact heavily on this market segment. Also, South Africa is a net importer of distillates and spirits and the stronger Rand will result in cheaper imports, putting further downward pressure on the prices of these varieties. Furthermore, a possible explanation why the impact on the price of Colombar is larger than that of Chenin Blanc is the response of change in vines in production. By 2015 the number of Chenin Blanc vines declined by 0.25% whereas Colombar increased by 0.15%. This can be explained by the fact that in 2007 over 40% of Chenin Blanc vines are 20 years and older, compared to the 23% of Colombar, so one would expect more Chenin Blanc uprooting than Colombar uprooting.

Figure 5 presents the impact on vines in production for the different wine producing regions. These clearly illustrate the benefit of the model structure (discussed in section III) in the sense that a distinction can be made between the impact of the exchange rate shock at

Figure 5
Vines in Production per Region
Percentage Change from Baseline



a national and regional level. Figure 5 illustrates that the Orange River region is projected to experience the biggest contraction in the wine industry, resulting from an appreciation in the exchange rate. This can be explained by the fact that Chardonnay, Colombar and Sultana are the main varietals planted in the Orange River area. In the case of Orange River, the contraction shown in the Figure may not represent actual decline in vines, but rather represent a decline in vines applied for wine making purposes. Sultana vines account for almost one third of vines in the Orange River region. It is expected that with the relatively lower prices a relatively larger proportion of these grapes will be allocated to the raisin market. Vines in production in the Stellenbosch region experience the second largest contraction; however the researchers have not plausible explanation for this phenomenon. Considering that Stellenbosch is predominantly a red wine producing region with huge capital investments in the form of small cellars, one would expect a much smaller impact on vines in production. This result highlights the problem of the limited number of observations used in estimating the equations, especially considering that the 13 years of observations include the time period when area planted to red wine grapes increased significantly.

VI. Conclusion

This paper has presented a partial equilibrium framework for modeling long term commodities as well as the usefulness of a simulation model for decision-makers in the South African wine industry. Baseline projections provide the industry with a benchmark of possible prices, production, consumption and trade under a certain set of assumptions.

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This benchmark can be used to better understand the impact of external shocks on the industry by means of calculating the absolute and percentage deviations from the baseline once a shock has been introduced in the model. However, the true usefulness of simulation models of this nature lies in the analysis of multiple shocks: in other words, the impact of a combination of shocks on the industry. These shocks include shifts in weather patterns, policy and tax structures, world prices, income, population and many more. Scenario planning can be useful to design a sequence of possible events/shocks that can be introduced in the model. Scenarios represent a sequence of events that take place in a logical way in order to present the possible outcome of reality (Meyer, 2006). Industry role players now have a tool that provides them the opportunity to better understand the possible impact of external shocks on the industry and how these shocks could influence their business. These models can, therefore, serve as an educational tool by teaching the modeler and the decision makers more about the dynamics of the industry.

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