WALRASIAN AND MARSHALLIAN STABILITY: AN APPLICATION TO THE AUSTRALIAN PIG INDUSTRY

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No. 254
April 1999

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April 1999

Discussion Paper No 254

ISSN 1033-4661

Walrasian and Marshallian stability: An application to the Australian pig industry*

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27 April 1999

Abstract

The Global Correspondence Principle of Samuelson states that global comparative static results hold even in the absence of an initial stable equilibrium. This principle has been applied in recent studies of international trade with variable returns to scale to resolve paradoxical results with respect to the Rybczynski and Stolper-Samuelson theorems. Takayama and Ide have shown that the principle may only apply if the initial equilibrium is Marshallian stable. This has implications for economic forecasting, in that forecasts of prices and quantities may only be valid in the presence of Marshallian stability. We estimate a Vector Error Correction Model of the Australian pig industry and examine the stability of the model in both the Walrasian and Marshallian sense. We find that prior to the introduction of imports in 1990 the farm gate market was characterised by both Walrasian and Marshallian stability and after 1990 it was unstable in both senses. This suggests that market forecasts since 1990 need to be viewed with more than the usual caution.

Keywords: Marshallian and Walrasian Stability, Vector Error Correction Models, Impulse Response Functions, Speed of Adjustment, Pig Industry.

JEL Classification: C32, C53, C62, F17, Q17

*A previous version of this paper was presented at the 43^{rd} Annual Australian Agricultural and Resource Economics Society Conference. Christchurch, New Zealand. 20-22 January 1999. We are grateful to Sam Strong and Eric Van Tassel for their comments

1. Introduction

In a series of recent papers Ide and Takayama [14], [15], [16], [17] discuss the implications for the stability of market equilibrium in international trade models characterised by perfectly mobile factors but incorporating factor market distortions and variable returns to scale. These studies rely heavily on the global correspondence principle of Samuelson [38], which states that in a comparative static setting, even if the initial equilibrium is unstable, the resultant equilibrium will be stable. However, in the presence of factor market distortions, imperfect competition and scale economies the global correspondence principle does not in general hold - resulting in apparently perverse Stolper-Samuelson and Rybczynski effects due to the instability of market equilibrium. In order to resolve these difficulties Ide and Takayama show that all one needs to do is establish that the market equilibrium is Marshallian stable. If the market is Marshallian stable then Samuelson's global correspondence principle applies, even if the market is Walrasian unstable. If, however, the market is not Marshallian stable then the global correspondence principle no longer holds and comparative static analysis is no longer valid.

This in turn has implications for microeconomic reform and trade deregulation in agricultural markets. There has been recent debate on the relative Pro's and Con's of trade liberalisation with respect to the Australian pig industry. The argument for liberalisation has been based on the gains from trade argument, in that the reduction in tradable commodity prices will lead to a reduction in consumer prices and thus an increase in consumer welfare. The reallocation of factors from the previously protected domestic industry to more efficient industries will result in an increase in those industries' output and a corresponding shift in the production possibility frontier.

General equilibrium analysis of trade reform has highlighted the gains from trade based on models characterised by constant returns to scale and perfect competition (See for example [39]). Even in the presence of imperfect competition and variable returns to scale gains from trade may be possible (but not certain) [23], [21]. The significance of the work of Ide and Takayama is that these results are based on the assumption of Marshallian stability, even in the presence of Walrasian instability.

Empirically, there is evidence to suggest that all real systems are in fact Marshall stable and Neary [25, 26] shows that the Stolper-Samuelson and Rybczynski paradoxes are never observed in reality. This result appears to hold in a long-run equilibrium setting but in the presence of structural change there is a question of whether the short-to-medium-run equilibrium is in fact Marshallian stable and consequently whether the Stolper-Samuelson and Rybczynski effects are perverse.

As stated above, this gain from trade effect is contingent on the underlying equilibrium being Marshallian stable. It is of interest, therefore, to see if the markets under examination are in fact characterised by Marshallian and/or Walrasian stability. In this paper we examine this question using data from the Australian pig industry.

In section 2 we discuss the difference between Walrasian and Marshallian stability before reconciling the comparative static notion of market equilibrium and its associated stability with the stability of econometric systems in section 3. We then conduct an econometric analysis of the stability of the Australian pig industry in section 4. We conclude in section 5.

2. Background on Walrasian and Marshallian Stability

The history of Walrasian and Marshallian stability is fraught with difficulties, errors and confusion. The textbook, or contemporary, definition of the difference between the two stability concepts distinguishes them in terms of whether the adjustment (tâtonnement) process is defined in terms of price (Walras) or quantity (Marshall). The difference between Marshallian and Walrasian stability can be seen in a simple cobweb model (See Figure 2.1) where the direction taken from an initial disturbance from the equilibrium determines stability in the Marshallian or Walrasian sense. In Marshall's view of stability in the theory of production, quantities responded to a change in price and in Walras view of stability in the pure theory of exchange, prices responded to a change in quantities. Thus Marshallian responses can be viewed as a clockwise adjustment and Walrasian responses can be viewed as a counter clockwise adjustment. Marshall viewed output as the response variable whereas Walras viewed prices as the response variable. For a particular set of demand and supply curves the market equilibrium may be Marshallian stable and at the same time Walrasian unstable.

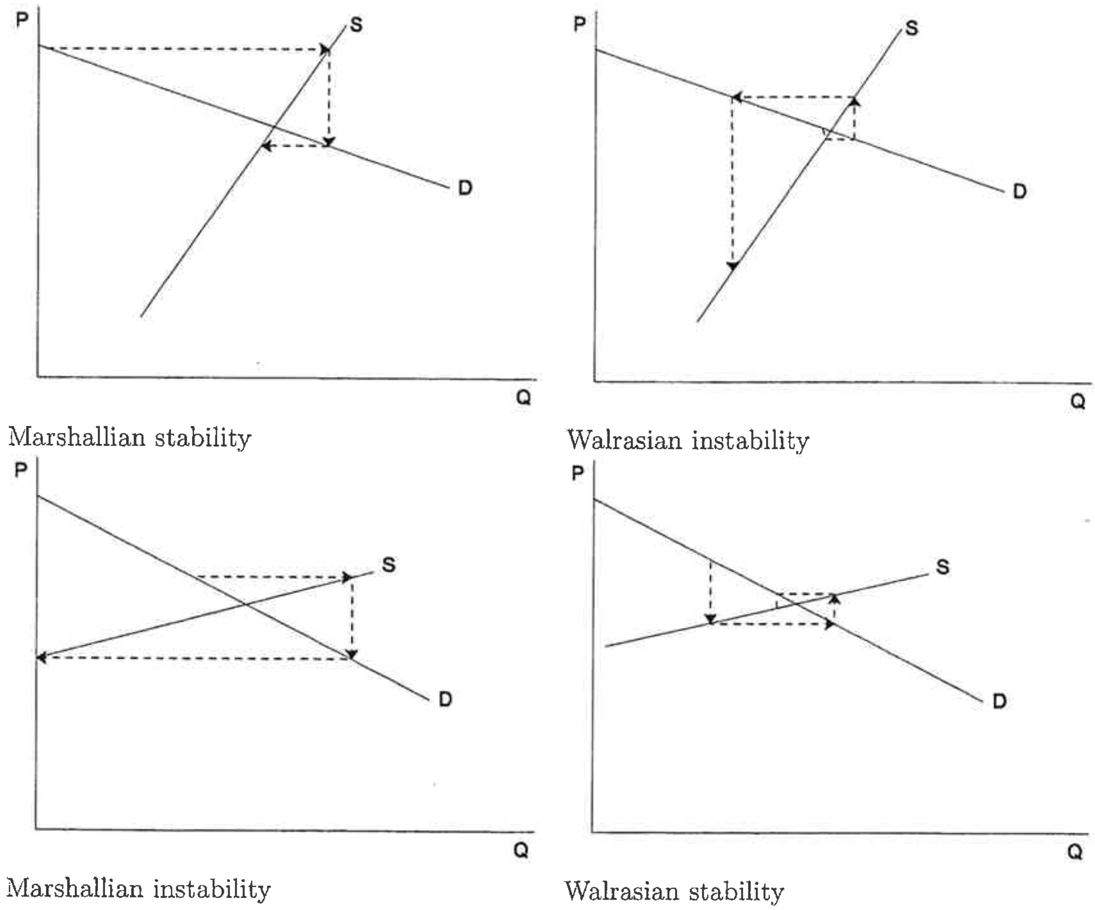

Figure 2.1: Marshallian and Walrasian stability

This is, however, not the whole story. Newman [35, p. 107] has stated the difference between Walrasian and Marshallian stability, and the confusion arising in the minds of some neoclassical authors concerning the interrelationship between the two concepts, may be attributed to the failure of neoclassical economists to appropriately distinguish between exchange and production in the same clear way that classical economists had done; Walrasian stability is associated with the theory of pure exchange and Marshallian stability is associated with the theory of production.

A good exposition of the contemporary view is provided by Takayama [34]. Takayama shows that the stability of a market can be expressed in either price or quantity dependent form

$$\dot{p} = k\left[D\left(p\left(t\right)\right) - S\left(p\left(t\right)\right)\right] \tag{2.1}$$

$$\dot{q} = \tilde{k}\left[D\left(q\left(t\right)\right) - S\left(q\left(t\right)\right)\right] \tag{2.2}$$

where $\dot{p} = \frac{dp}{dt}$, the excess demand is given by $D\left(p\left(t\right)\right) - S\left(p\left(t\right)\right)$, and $k > 0$ is the speed of adjustment of the market; similarly for the quantity dependent form [34, p. 297][1]. These two stability concepts (price versus quantity dependent) have been referred to in the literature asWalrasian and Marshallian stability respectively. However, as Newman [35] points out, Walrasian stability refers to the stability of the exchange process - an instantaneous, tâtonnement process - whereas Marshallian stability refers to the stability of the production process - a short-run process. As such, the two measures of stability cannot be compared in the same dimension. These views may be summarised in Table 2.1.

Table 2.1: Alternative concepts of stability

	Marshallian	Walrasian
Original view	Short-Run	tâtonnement
Contemporary view	Quantity	Price

Takayama goes further [34], and suggests that both Walras and Marshall realised the time scale difference between production and exchange and both quantity and price adjusted simultaneously in the two processes. That is, in the Marshallian view of production there was a convergence of both prices and quantities to the market equilibrium in the short run [24, pp. 345,347] and in the Walrasian view of exchange there was a convergence of both prices and quantities to the market equilibrium via a tâtonnement process [40, p. 504].

Takayama [34] discusses the tâtonnement process as envisaged by Walras in that the process is seen as an adjustment in prices between buyers and sellers before any actual trade has taken place. The tâtonnement process can be viewed as simultaneous or successive between markets. Walras envisaged the successive case where prices were adjusted one market at a time until all markets were in equilibrium. If the markets converge to equilibrium then the tâtonnement process is seen as being stable. Takayama also discusses the non-tâtonnement process, where the intermediate transactions and actual purchases change the excess demand function. If the excess demand function is changed at every point in time due to actual purchases taking place then the static notion of stability no longer holds. Takayama notes that in this case the eventual equilibrium reached will depend on the time path of the tâtonnement process.

[1]Note the quantity dependent form really involves an abuse of notation as $D(q)$ really is the inverse function of $D(p)$ and similarly for $S(.)$.

The link between comparative static and dynamic stability analysis was provided by Samuelson's *correspondence principle*[38, p. 258]. Samuelson showed the circumstances under which Hicksian notions of stability could be equivalent to his dynamic approach. Hicks' notion of stability [37] distinguishes between two types of stability, imperfect and perfect stability, when taking a comparative-static general equilibrium approach. A market was defined as being **imperfectly stable** if there is stability in that market with all other markets held in equilibrium. Following from this, the economy was defined as being imperfectly stable if all the markets in that economy were imperfectly stable. A market was defined as being **perfectly stable** if the imperfect stability in that market holds regardless of the adjustment or not of the other markets, and the economy was perfectly stable if all markets were perfectly stable. Like Walras and Marshall, Samuelson [38] took a dynamic view of the stability of an economy by analysing the stability properties of a system of differential equations. If the time path of the system converged to an equilibrium price vector then the system was said to be **truly dynamically stable**. Our interest in stability in a comparative static framework and thus the implications for trade policy is through the global correspondence principle. As stated earlier, Ide and Takayama have shown that the perverse Stolper-Samuelson and Rybczynski effects under variable returns to scale in a comparative static framework disappear when Marshallian stability is present.

Davies [10] points out that Marshallian and Walrasian stability in the contemporary sense (output and price adjustment) leads to identical results if the demand and supply curves are of conventional shape - that is, demand is negatively sloped and supply is positively sloped. If supply is negatively sloped then the results are no longer consistent. It is therefore an empirical question whether supply is positively sloped. Davies goes on to ask whether there is any theoretical basis for choosing between an output versus a price adjustment model, irrespective of the empirical findings. In doing so he examines the original meanings of the two concepts of stability and equates the output adjustment model with the long-run theory of production versus the price adjustment model with the theory of exchange. With this, Davis points out an error in the contemporary interpretation of Marshall's negatively sloped supply function as being a backward rising supply function as opposed to being a forward falling long-run curve due to external economies of scale. With this correction to the interpretation of the Marshallian supply function it can be seen that both Marshall and Walras developed models of price and output adjustment, and that a backward rising supply curve is appropriate for models looking at the pure theory of exchange and a forward falling supply curve is appropriate for models looking at the pure theory of production.

Part of the literature on international trade under imperfect competition [23], [20], [21], concentrates on the idea that with variable returns to scale and factor market distortions (the non-tangency and non-convexity violations of the gains from trade theorem) the gains from trade are at best uncertain, and that the validity of the Stolper-Samuelson and Rybczynski theorems[2] are neither necessary nor sufficient for the production possibility frontier to be locally strictly concave to the origin [29, pp.

[2]The Stolper-Samuelson theorem states that if there are constant returns to scale and if both goods continue to be produced, a relative increase in the price of a commodity will increase the real return to the factor used intensively in that industry and reduce the real return to the other factor. The Rybczynski theorem states that if relative commodity prices are constant and if both commodities continue to be produced, an increase in the supply of a factor will lead to an increase in the output of the commodity using that factor intensively and a decrease in the output of the other commodity.

511,514].

Under Marshallian stability Ide and Takayama [16] have shown that even in the presence of variable returns to scale in external scale economies the Stolper-Samuelson and Rybczynski theorems still hold. If we do not have Marshallian stability then there is an apparent paradox:

> If prices go up, then under variable returns there is the question of whether to increase production, i.e. price-setting behaviour or market power. For the industry as a whole there is a downward sloping demand curve but for individual firms they view the demand curve as being perfectly competitive.

This has implications for the Stolper-Samuelson and Rybczynski theorems where there is a lack of correspondence under this proposition. The lack of correspondence is that the Stolper-Samuelson theory only holds in the presence of factor market distortions in the value sense but not in the physical sense (i.e., the factor market intensity is measured in the value sense but not the physical sense), whereas the Rybczynski theorem holds for both the value and physical sense.

Not only don't the Stolper-Samuelson and Rybczynski theorems hold under variable returns to scale and factor market distortions but the factor price equalisation theorem[3] also does not hold, resulting in a perverse effect:

> ...at constant commodity prices an increase in a subsidy paid to one sector...will reduce the output of that sector and its employment of both factors [26, p. 500].

As with the apparently perverse Stolper-Samuelson and Rybczynski responses this apparently perverse distortion-output response disappears if the market is Marshallian stable.

Ide and Takayama [17] show that under the Global Correspondence Principle, policy conclusions can be drawn from a system that is Walrasian unstable (i.e. the resulting equilibrium is Walrasian stable) if the system is Marshall stable. They also show that under Marshallian stability the Stolper-Samuelson effect will be small with a small change in the parameters and the Stolper-Samuelson effect will be large with a large change in the parameters.

3. Measuring Walrasian and Marshallian stability

In the previous section the different interpretations of Walrasian and Marshallian stability were outlined. The original interpretation was that Walrasian stability referred to the stability of the exchange process - an instantaneous, tâtonnement process - whereas Marshallian stability referred to the stability of the production process - a short-run process. In contrast the contemporary interpretation distinguishes them in terms of whether the adjustment (tâtonnement) process is defined in terms of price (Walras) or quantity (Marshall).

Irrespective of whether you view the difference between Marshallian and Walrasian stability to be a difference between the short-run and tâtonnement, versus a difference

[3] The factor price equalisation theorem states that under identical constant returns to scale production technologies, free trade in commodities will equalise relative factor prices through the equalisation of relative commodity prices, so long as both countries produce both goods.

between quantity and price, the econometric methodology of non-stationarity and cointegration is an apt framework to conduct empirical tests of stability. In this section we attempt to reconcile the concepts of Marshallian and Walrasian stability with the econometric concepts of stability, referring to unit roots of difference equations (See Enders [12] for an exposition)[4]. For the n^{th}-order linear difference equation in univariate form

$$y_t = a_0 + \sum_{i=1}^{n} a_i y_{t-i} + x_t \tag{3.1}$$

we have a homogeneous solution

$$y_t - \sum_{i=1}^{n} a_i y_{t-i} = 0 \tag{3.2}$$

In econometric models the usual requirement for stability is that all the characteristic roots lie within the unit circle

$$\sum_{i=1}^{n} |a_i| < 1 \tag{3.3}$$

Since we define a process as being stationary if it does not have a unit-root, then a stationary process is necessarily stable.

For systems of linear difference equations, for example a Vector Autoregessive (VAR) model, we have the n-variable system

$$x_t = A_1 x_{t-1} + \epsilon_t \tag{3.4}$$

where x_t is a $(n \times 1)$ vector of variables y_{it}. In difference form

$$\Delta x_t = (A_1 - I)\, x_{t-1} + \epsilon_t \tag{3.5}$$

$$\Delta x_t = \pi x_{t-1} + \epsilon_t \tag{3.6}$$

where the rank of π, the long run multiplier matrix, is the number of cointegrating vectors. If $rank\,(\pi) = 0$ then all the $\{\Delta x_{it}\}$ sequences are unit root processes and there is no stationary linear combination of the $\{x_{it}\}$ sequences and thus the variables are not cointegrated and the system is unstable. If π is of full rank, $rank\,(\pi) = n$, then all the variables are stationary and the system is stable. In the intermediate case if π is rank deficient, $rank\,(\pi) = r$, then there are r linearly independent combinations of the $\{x_{it}\}$ sequences that are stationary and thus those $\{x_{it}\}$ are said to be cointegrated. If we include these cointegrating vectors into our model specification as an Error Correcting Mechanism (ECM) we impose stationarity on the model as a whole and thus the model is stable.

If we let the market for a particular commodity be represented by demand and supply equations:

$$q_t^d = a - \gamma p_t \tag{3.7}$$

$$q_t^s = b + \beta p_{t-1} + \varepsilon_t \tag{3.8}$$

$$q_t^d = q_t^s \tag{3.9}$$

[4] We consider discrete time systems and ignore the issue of whether the true model is discrete or continuous in order to simplify the analysis. We would like however to point out that the following analysis could equally be done in continuous-time (See Comte [9] for example).

where $q_t^{d,s}$ is quantity demand and supplied in period t, p_t is the market price, with producers basing production decisions on lagged prices, and $\gamma, \beta > 0$ and ε_t $iid\left(0, \sigma^2\right)$ then the market price is

$$p_t = -\frac{\beta}{\gamma} p_{t-1} + \frac{(a-b)}{\gamma} - \frac{1}{\gamma} \varepsilon_t \tag{3.10}$$

which has a general solution (See [12, pp. 20-25] for the derivation)

$$p_t = \frac{(a-b)}{(\gamma+\beta)} - \frac{1}{\gamma} \sum_{i=0}^{t-1} \left(-\frac{\beta}{\gamma}\right)^i \varepsilon_{t-i} + \left(-\frac{\beta}{\gamma}\right)^t \left[p_0 - \frac{(a-b)}{(\gamma+\beta)}\right] \tag{3.11}$$

The stability of the market is shown by the ratio of the slopes of the supply and demand curves, $\frac{1}{\beta}$ and $\frac{1}{\gamma}$ respectively. If $\frac{\beta}{\gamma} < 1$ then the market is stable and market price converges to the equilibrium. The long-run equilibrium price is defined as $\frac{(a-b)}{(\gamma+\beta)}$ and the impact multiplier, $\frac{\partial p_t}{\partial \varepsilon_t}$, is $-\frac{1}{\gamma}$. The time path of the multiplier is the impulse response function, which is defined as

$$\frac{\partial p_{t+n}}{\partial \varepsilon_t} = -\frac{1}{\gamma} \left(-\frac{\beta}{\gamma}\right)^n \tag{3.12}$$

The final component of the general solution is the initial deviation of price from its long run equilibrium, $p_0 - \frac{(a-b)}{(\gamma+\beta)}$. The time path of the adjustment of the system back to equilibrium gives an idea of its stability. Such a time path is represented by the impulse-response function of the price equation.

The original view of Walrasian stability is that this is the stability of the tâtonnement process in a pure exchange economy, and turning to an econometric equivalent we can note that observed price and quantity vectors are final equilibrium vectors and that the tâtonnement process can be equated to the within-period adjustment of prices. In such a scenario it is of interest to determine whether prices are stationary (implying stability) or non-stationary (implying instability). The contemporary view of Walrasian stability is that this is the stability of the price equation rather than the tâtonnement process; econometrically, since we only observe equilibrium prices and quantities, it is perhaps more useful to concentrate on the non-tâtonnement process and the time path of the adjustment of the market price equation back to equilibrium to get an idea of the stability of the market price. Recalling that in the VAR framework, if the long-run multiplier matrix is rank deficient, there are r linearly independent combinations of the $\{x_{it}\}$ sequences that are stationary which are said to be cointegrated. Therefore we can move to a Vector Error Correction (VEC) framework which incorporates an ECM. However, Pesaran and Shin [31] have shown that due to the rank deficiency of the long-run multiplier matrix the impulse-response functions will be persistent and will not generally die out. In such a case a more useful measure of the stability of a particular equation is the impulse-response function of the cointegrating vector in the particular equation under investigation and a measure of the stability of the system as a whole is the persistence profile of the ECM.

The original view of Marshallian stability is that this is the stability of the short-run, in the pure theory of production. Turning to an econometric equivalent we can note that in a system of equations representing a market, the Marshallian short-run is analogous to the long-run error correction mechanism (ECM). Thus the stability of production can be viewed as the stability of the ECM. Having noted Takayama's [34]

Table 3.1: Alternative concepts of stability

	Marshallian	Walrasian
Original view	Persistence Profile	Unit-Roots
Contemporary view	Quantity equation IR	Price equation IR

observation about the non-tâtonnement process and how the excess demand function changes over time due to actual transactions taking place, it is probably useful to observe the time path of the ECM back to equilibrium to get an idea of the stability of the market. This is represented by the persistence profile of the system wide ECM [31]. The contemporary view of Marshallian stability is that this is the stability of output and econometrically this would be equivalent to the stability of the equilibrium quantity in the market. In the non-tâtonnement process the time path of the adjustment of production back to equilibrium is an indication of the stability of production. Like the contemporary view of Walrasian stability we can view the impulse-response function of the cointegrating vector in the production equation as a measure of the stability of production.

To summarize, in an econometric model incorporating a long run equilibrium relationship, the original view of Marshallian stability is equivalent to measuring the persistence profile of the ECM, the original view of Walrasian stability is equivalent to measuring the stationarity or non-stationarity of prices, and the contemporary view of both are the impulse-responses of the ECMs of the individual quantity and price equations respectively (See Table 3.1).

4. Stability in the Australian pig industry

Australia, given its high-profile role in multilateral trade liberalisation negotiations, places particular emphasis on the gains from trade accruing from the removal of barriers to trade. However, while these barriers to trade are seen primarily as being external or border distortions, internal or domestic distortions are down played or to a large extent ignored. According to Ide and Takayama [17] the stability of a market is important in obtaining valid comparative static results, which is particularly important in a policy setting.

Since factor market distortions and variable returns to scale in a domestic economy result in the gains from trade being uncertain at the best of times, the result that these gains also hinge crucially on the long-run stability of the market deserves some investigation. We apply this to the Australian pig industry, and measure the stability of the market. This is a rather apt market to examine, as in recent years the industry has moved from a position of relative autarchy to free trade. The recent history of the Australian pig industry is that prior to 1990 there was a zoosanitary barrier to imports, the removal of which saw gradual increases in imports of pigmeat from Canada. Seasonal unit root tests undertaken by Purcell and Harrison [32] suggest that prior to 1990 prices and quantities were stationary but the introduction of imports resulted in a structural break with producer prices becoming non-stationary. We use the same dataset as Purcell and Harrison in this analysis.

Testing for stability of the market requires that we are able to form a system of simultaneous equations and derive the impulse response functions to examine the time path of the speed of adjustment of the market back to equilibrium. A VAR model fits this description but suffers from the problem that non-stationary variables within the VAR model may be cointegrated and fitting a VAR without an error correction mechanism (ECM) may lead to cointegration bias. The results of the unit root tests (See Table 4.1) suggest that prior to the commencement of imports the saleyard price for baconers, or the producer price for pigs, was stationary and the other variables of interest were non-stationary. In this situation we need to move to a Vector Error Correction (VEC) model framework which incorporates an ECM.

Table 4.1: Pig Industry Dataset

	<1990Q1 $SI_s(d,D)$	>1990Q1 $SI_s(d,D)$	Deterministic Seasonality
Saleyard price for baconers (¢/kg) (SPQ)[1]	$I(0)$	$I(1)$	$Q_t^1, Q_t^2, Q_t^3, Q_t^4$
Saleyard price for beef cattle (¢/kg) (SBFQ)[1]	$I(1)$	$I(1)$	
Retail price for pork (¢/kg) (RPQ)[1]	$I(1)$	$I(1)$	
Imports of pigmeat from Canada (kg) (CAMVQ)[6]	NA	$SI_4(0,1)$	
Price of imports from Canada (¢/kg) (CAMPQ)[6]	NA	$SI_4(0,1)$	
Domestic production of pigmeat (kg) (PPDQ)[3]	$I(1)$	$I(1)$	Q_t^1, Q_t^2

4.1. The Australian pig industry - pre trade

As a first step, the order of the VAR needs to be determined[5]. The AIC and SBC were calculated for a VAR model with the endogenous variables SPQ, SBFQ, RPQ, PPDQ and the exogenous variables being a constant, time trend and the 1^{st} to 3^{rd} quarterly dummies over the period 1984:4 to 1990:2 (the period before actual imports commenced). The results are presented in Figure A.1. Taking into consideration the principle of parsimony both the AIC and SBC select a lag length of one (1) as being optimal. The results suggest that an AR(1) process is adequate in capturing the data generating process underlying market supply and demand in the Australian pig industry over the period under review.

Once the lag length has been determined the number of cointegrating vectors for the non-stationary variables need to be identified. The Johansen Maximum Likelihood test for cointegration is carried out on the variables (SPQ, SBFQ, RPQ, PPDQ) with unrestricted intercepts and trends and the 1^{st} to 3^{rd} seasonal dummies over the period 1984:2 to 1990:2 with one lag length. The test statistics are presented in Table A.1. The test reveals that there appears to be 2 cointegrating vectors (See Table A.2)[6].

Given that there appears to be two cointegrating vectors specifying the long-run equilibrium relationship in the Australian pig industry we estimate a VEC(1,2)[7] model which is presented in Table 4.2[8].

The results indicate that the first cointegrating vector plays a highly significant role in the determination of the domestic pig market equilibrium, with saleyard prices,

[5] The order of the VAR is a crucial determinate of the results, as extra lags included in the model leads to an over parameterisation of the model and a consequent dilution of the significance of the variables within the model.

[6] It is normally assumed that stationary variables cannot be including in an ECM, since the ECM requires that the variables be integrated of the same or higher order. However, Hansen and Juselius [36, p. 1] point out that all that is required is that two of the variables in the ECM are non-stationary. Stationary (and near-integrated variables) often play an important role in the long-run equilibrium relationship and should be included in the ECM. Tests of over-identifying restrictions on the cointegrating space indicate that the stationary variable, SPQ, cannot be eliminated from the

Table 4.2: pre-trade VEC model representation for pig industry

	ΔSPQ		$\Delta PPDQ$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]
α_0	−164.1597	68.0750[0.027]	4.21×10^7	1.27×10^7[0.004]
T	−1.8465	0.68710[0.015]	357587.6	128351.8[0.012]
ECM^1_{t-1}	21.0192	6.7555[0.006]	−6402859	1261940[0.000]
ECM^2_{t-1}	−4.0297	6.7555[0.558]	−587261.7	1261940[0.647]
Q^1_t	−23.6495	3.9684[0.000]	−6212793	741305.9[0.000]
Q^2_t	4.4804	9.6462[0.648]	−80896.8	1801930[0.965]
Q^3_t	6.5288	4.4503[0.160]	188650.7	831318.6[0.823]
R^2	0.84303		0.95451	
	ΔRPQ		$\Delta SBFQ$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]
α_0	−79.8888	69.1554[0.263]	−223.1551	79.9025[0.012]
T	−0.34655	0.69800[0.626]	−2.3658	0.80648[0.009]
ECM^1_{t-1}	21.0860	6.8627[0.007]	−0.23029	7.9292[0.977]
ECM^2_{t-1}	9.1851	6.8627[0.197]	−31.5793	7.9292[0.001]
Q^1_t	−0.22413	4.0314[0.956]	0.65470	4.6579[0.890]
Q^2_t	7.2709	9.7993[0.468]	29.9358	11.3221[0.016]
Q^3_t	5.3597	4.5209[0.251]	12.1530	5.2235[0.032]
R^2	0.61172		0.65242	

domestic production, and retail prices linked together by the first cointegrating vector. This first cointegrating vector does not play an important role in the determination of domestic cattle prices, which is to be expected. Similarly, the second cointegrating vector is highly significant in the determination of domestic cattle prices, but not in the determination of pig industry variables. This indicates that there is further scope for testing of weak exogeneity between the cattle and pig markets[9]. The relatively low R^2 for retail prices for pork and cattle prices indicates that the estimated model is a poor representation of the data generating process (DGP) underlying these two price series. In contrast the producer level variables of the pig industry (producer prices, saleyard prices for baconers, and production volumes) have a high level of their respective DGPs explained by the estimated model. This highlights both the exogeneity of cattle prices and the asymmetric price transmission between producer and retail prices (saleyard prices for baconers and retail prices for pork) found by Purcell and Harrison [32]. The high R^2 for the model equations indicate that the model is an adequate representation of the market structure over the time period

error correction mechanism as it plays a significant role in the long-run equilibrium relationship.

[7] That is, 1 lag with 2 ECMs.

[8] None of the equations showed evidence of significant autocorrelation or heteroscedasticity. The equation for SPQ showed non-significant (but borderline, p=0.056) ARCH(2). On balance there does not appear to be any indication of a ARCH process.

[9] This point is interesting, as it gives further evidence of the exogeneity between the cattle and pig markets, previously highlighted by Purcell and Harrison [32], and highlights a common misconception as to the relationship between falling cattle prices and falling pig prices - cited by ABARE [2] and the Australian Government [4], [5] as a prime reason for the pig industry's recent hardship (post November 1997). This misconception arises from the confusion between the substitutability between beef and pork, and the (lack of) substituability between cattle and pigs - due to the presence of middlemen with market power.

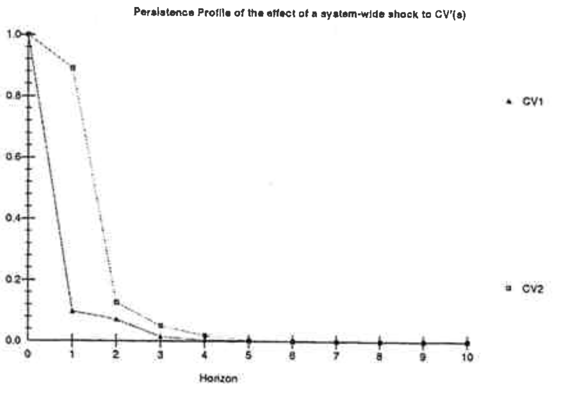

Figure 4.1: Persistence profile of the cointegrating vectors in the pre-trade VEC model

1984:4 to 1990:2.

Once we have specified the model structure, we need to turn to the analysis of Marshallian and Walrasian stability of market. As mentioned above, we can view these two concepts of stability in two ways - the original and the contemporary concepts (See Tables 2.1 and 3.1). In the original concept, where market stability was seen in terms of production and exchange, Marshallian stability was viewed as a short-run return to equilibrium of the market. We can examine the persistence profile of the cointegrating vectors to get an idea of the speed of adjustment of the market back to equilibrium (See Figure 4.1). The speed of adjustment of the market back to equilibrium is reasonably fast, taking around five quarters for shocks to the market equilibrium to dissipate. The domestic pig market is quite stable, with most of the shock to equilibrium dissipating within the first time period (quarter) after the shock. The second cointegrating vector, for the saleyard price of cattle, indicates that (for the data generating process as specified by the model) the speed of adjustment for cattle prices is slightly slower - with most of the shock to the market equilibrium dissipating within two quarters. The final convergence back to equilibrium for the saleyard price of cattle takes the same time as for the pig market. Again, the cattle market is not fully specified in the model and inferences should be drawn with caution.

In its original concept, Walrasian stability can be seen as an instantaneous return to equilibrium, or a tâtonnement process, in the exchange economy. In the market we are interested in, the producer level of the pig market, the tâtonnement process is in the instantaneous adjustment of buyer and seller prices towards the realised price. As shown above, non-stationarity (that is, an $I(1)$ variable) in an econometric sense is shown to be equivalent to the instability of a first-order difference equation. The results (See Table 4.1) show that the saleyard price for baconers is stationary and therefore Walrasian stable.

In the contemporary view of Walrasian and Marshallian stability, stability is seen in terms of prices and quantities, rather than instantaneous and short-run. We can view the impulse-responses of the individual ECMs as measures of this stability process. Shocks to the cointegrating vectors show the short-run speed of adjustment of the market equations back to their equilibrium (See Figure 4.2). The impulse-responses are shown for both cointegrating vectors for each of the equations in the

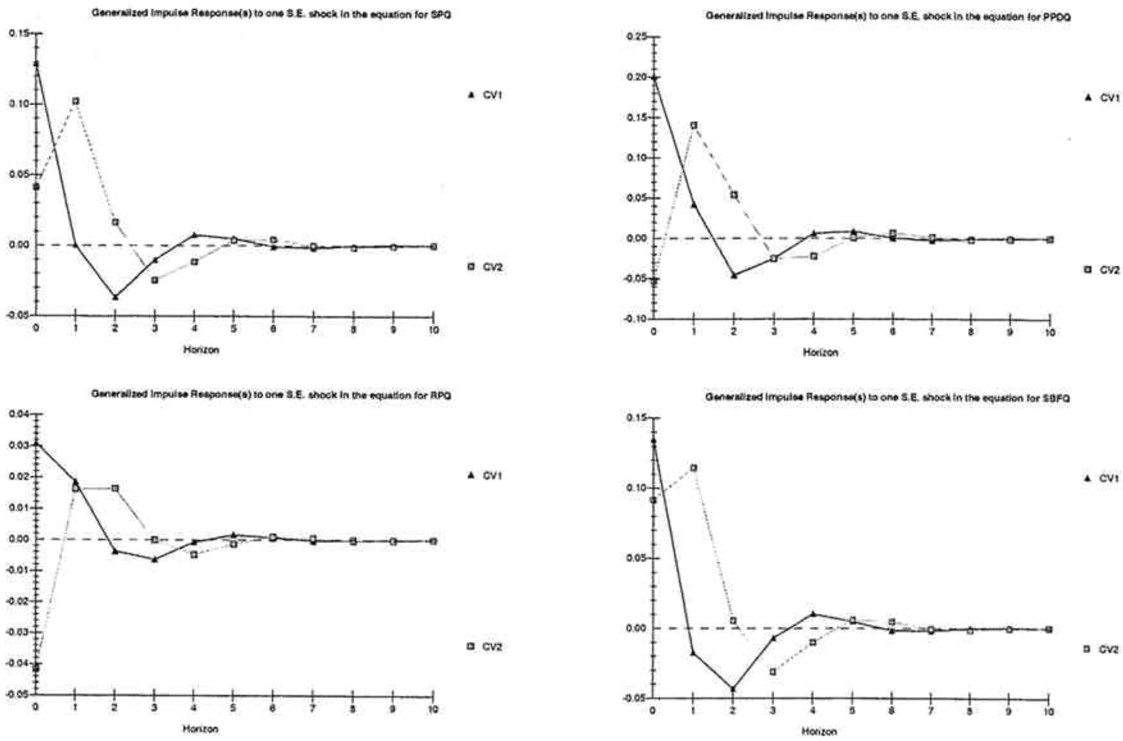

Figure 4.2: Impulse-responses for cointegrating vectors in the pre-trade VEC model

VEC model, although the coefficients of the ECMs indicate that only the first cointegrating vector is significant for the pig variables (SPQ, PPDQ, RPQ) and the second cointegrating vector being significant for cattle prices (SBFQ).

The results show that the speed of adjustment of producer prices and production is moderate, with both regaining equilibrium within 7 quarters of an initial shock. Most of the shock in producer prices and production has dissipated within one year (4 quarters) with producer prices being less responsive to a shock, in that there is less overshooting of the equilibrium for the cointegrating vector in the producer price equation compared with the cointegrating vector for the production equation. Retail prices are more robust to market shocks than producer prices or production, as evidenced by the quite small deviations from equilibrium shown in the impulse-response functions for the retail price equation. Most of the shock dissipates within the first time period (quarter). This is indicative of the retail market being insulated from external shock, compared with the producer market, and further evidence of the asymmetric price transmission between retail and producer prices found by Purcell and Harrison [32]. Cattle prices also show a moderate speed of adjustment, with equilibrium being regained within 7 quarters of an initial shock. Most of the shock dissipates within 2 quarters with some slight overshooting of the equilibrium shown in the third quarter before a slow dampening down of the shock.

Using the contemporary interpretation of Marshallian and Walrasian stability the results indicate that both production and prices are stable with moderate speed of adjustment back to market equilibrium.

4.2. The Australian pig industry - post trade

From the above analysis it appears that the Australian pig industry under autarchy was characterised by both Walrasian and Marshallian stability, in both the contemporary and original sense. Since the introduction of imports has changed the nature of the market (See Table 4.1) it is of interest to see whether the market is still stable, as the predictions of the gains from trade are based on an underlying stability of the market.

We undertake the same procedure as before, and examine the market after the introduction of imports. As a first step, the order of the VAR needs to be determined. The AIC and SBC were calculated for a VAR model with the endogenous variables SPQ, SBFQ, RPQ, PPDQ and the exogenous variables being CAMVQ, CAMPQ, constant, time trend and the 1^{st} to 3^{rd} quarterly dummies over the period 1990:2 to 1998:2 (the period before imports commenced). The results are presented in Figure A.2. The SBC selects a lag length of one (1) as being optimal with the AIC showing no maximum value reached over the lag lengths used. Taking into consideration the principle of parsimony a VAR(1) was initially chosen as the most appropriate. However, the resulting VEC regression diagnostics were not particularly good for this model formulation. While there was no evidence of heteroscedasticity, ARCH or serial correlation, the R^2s indicate that the model was a poor fit of the DGPs, especially for the retail price of pork and the saleyard price of cattle (RPQ and SBFQ respectively). A more promising model specification results from over-fitting the VEC model by incorporating an additional lag, making a VEC(2) model.

It should be noted that the variables CAMVQ and CAMPQ were modelled as being $I(0)$ even though the DHF test indicated that they were in fact $SI_4(0,1)$. The incorporation of imports as $I(0)$ variables along with seasonal dummy variables was done as an alternative to pre-filtering the variables and incorporating them as seasonal differenced variables - with a corresponding reduction in degrees of freedom and loss of long run information. In other words, we explicitly assumed that the stochastic seasonality could be approximated by deterministic seasonality.[10] We address the question of whether imports should be included in the model structure as $I(1)$ variables later.

Although industry sources suggest that a build-up of imported stocks do have an influence on market forces, we decided to model CAMVQ and CAMPQ as having only a current period impact on the domestic industry. Allowing imports to have a two quarter lag in the model structure (the same as the other variables) results

[10] However, this is not the entire story. There has been some debate [18], [19], [22] as to the validity of the tests for seasonal stationarity undertaken by Purcell and Harrison [32] on which these results are based. It has been stated that the Dickey-Hasza-Fuller (DHF) test [11], [27] used is not as accurate as the alternative Hylleberg, Engle, Granger and Yoo (HEGY) test [13]. This is untrue, as recent work by Osborn and Rodrigues [28] show that they are asymptotically equivalent. What is true is that the HEGY test will give an indication of the frequency of seasonal integration; quarterly, bi-annually etc. whereas the DHF test indicates whether or not the series is seasonally integrated for that particular data frequency (i.e. quarterly data). HEGY tests carried out by the Institute for Research into International Competitiveness (IRIC) [19] indicate that import volumes and prices have a semi-annual unit root. As with the DHF tests carried out by Purcell and Harrison [32] the question then is whether the seasonally integrated import variables be included in the VEC model as $SI_n(0,1)$ variables (where n refers to the level of seasonal integration), $I(1)$ variables, or $I(0)$ variables with deterministic seasonal dummies to approximate the seasonal integration. Including the import variables as $SI_n(0,1)$ is more appropriate, but leads to a loss in degrees of freedom and long-run information and therefore treating the variables as $I(0)$ with seasonal dummy variables is a second best solution.

in significant heteroscedasticity in the equation for domestic production. This heteroscedasticity does not appear to follow an ARCH process. Reducing the lag length down to one lag eliminates the heteroscedasticity, but it is still borderline, with a p-value of 0.053. This indicates that the effect of imported stocks on domestic production is at best a fractionally lagged process, i.e. stock buildup of less than one quarter play more of a role in changes in domestic production than longer quarterly units. Thus specifying imports as having no lags and allowing the seasonal dummy variables to pick up systematic changes in import volumes and prices was deemed to be the more appropriate model formulation.

Once the lag length has been determined, the number of cointegrating vectors for the non-stationary variables need to be identified. The Johansen Maximum Likelihood test for cointegration is carried out on the endogenous variables (SPQ, SBFQ, RPQ, PPDQ) with exogenous $I(0)$ variables CAMVQ and CAMPQ, unrestricted intercepts and trends and the 1^{st} to 3^{rd} seasonal dummies over the period 1990:2 to 1998:2. The test statistics are presented in Table A.3 and reveals that there appears to be 1 cointegrating vector (See Table A.4).

Given that there appears to be one cointegrating vector specifying the long-run equilibrium relationship in the Australian pig industry we estimate a VEC(2,1)[11] model which is presented in Table 4.3.

The results indicate that the cointegrating vector is only significant for the retail price of pork, suggesting that the long-run equilibrium linkage between producer prices, retail prices, and production has been broken by the change in industry structure occurring after the introduction of imports in 1990.

Once we have specified the model structure, we need to turn to the analysis of Marshallian and Walrasian stability of market. To get an idea of the Marshallian stability of the market we can examine the persistence profile of the cointegrating vector which plots the time path of the speed of adjustment of the market back to equilibrium (See Figure 4.3). Since the ECM is only significant for the retail price for pork, the speed of adjustment refers to the retail price (or market level) only, not the producer market level of the domestic pig industry.

The speed of adjustment of the retail market back to equilibrium is reasonably fast, taking around five quarters for shocks to the market equilibrium to dissipate.. The domestic retail market for pork is quite stable, with most of the shock to equilibrium dissipating within the first two time periods (quarters) after the shock. In terms of the producer level of the market the absence of a significant ECM, the mechanism that returns the market to equilibrium after a shock, indicates that any shock to the market is likely to be a permanent one (or at least long lasting). The absence of an ECM for a non-stationary system suggests that the system is unstable in the original Marshallian sense. For the conventional concept of Marshallian stability we need to examine the quantity, or domestic production equation of the VEC system. The ECM for ΔPPDQ is also non-significant, indicating that any shock to production is likely to be a permanent one, or that it is such a slow return to equilibrium it is not significantly different from no return to equilibrium. Thus in both the original and contemporary view of Marshallian stability the domestic pig market at the producer level is unstable.

The original concept of Walrasian stability is that there is an instantaneous return to equilibrium, or a tâtonnement process, in the exchange economy. In the market we are interested in, the producer level of the pig market, the tâtonnement process is

[11] That is, 2 lags with 1 ECM.

Table 4.3: post-trade VEC representation for pig industry

	ΔSPQ		$\Delta PPDQ$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]
α_0	298.7248	229.8162[0.208]	5.18×10^7	4.90×10^{-7}[0.303]
T	1.4008	0.95830[0.159]	144614.9	204372.3[0.487]
ΔSPQ_{t-1}	0.036482	0.26889[0.893]	−141139.5	57344.2[0.023]
$\Delta SBFQ_{t-1}$	0.16767	0.20830[0.430]	−40004.0	44423.9[0.378]
ΔRPQ_{t-1}	−0.25703	0.36349[0.487]	2496.8	77519.5[0.975]
$\Delta PPDQ_{t-1}$	0.6731×10^{-6}	0.1194×10^{-5}[0.579]	−0.27360	.25471[0.295]
ECM^1_{t-1}	−15.3392	12.4131[0.230]	−2831177	2647275[0.297]
$CAMVQ$	-0.9886×10^{-5}	0.4666×10^{-5}[0.046]	0.58655	0.99513[0.562]
$CAMPQ$	−0.0030986	0.033206[0.927]	1725.9	7081.6[0.810]
Q^1_t	−26.5768	7.6022[0.002]	−4214848	1621284[0.017]
Q^2_t	−35.6860	12.7949[0.011]	3232672	2728702[0.249]
Q^3_t	0.18565	12.5895[0.988]	−1411073	2684896[0.605]
R^2	0.73500		0.85685	
	ΔRPQ		$\Delta SBFQ$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$[p-value]
α_0	619.8514	118.0466[0.000]	369.5686	228.3004[0.120]
T	2.3692	0.49224[0.000]	1.0173	0.95198[0.297]
ΔSPQ_{t-1}	0.056941	0.13812[0.684]	−0.17810	0.26711[0.512]
$\Delta SBFQ_{t-1}$	0.30361	0.10700[0.010]	0.0043583	0.20693[0.983]
ΔRPQ_{t-1}	−0.089414	0.18671[0.637]	−0.53458	0.36109[0.154]
$\Delta PPDQ_{t-1}$	0.1139×10^{-5}	0.6135×10^{-6}[0.078]	0.1844×10^{-5}	0.1186×10^{-5}[0.135]
ECM^1_{t-1}	−33.0831	6.3761[0.000]	−19.5101	12.3312[0.129]
$CAMVQ$	-0.2004×10^{-6}	0.2397×10^{-5}[0.934]	0.6931×10^{-5}	0.4635×10^{-5}[0.150]
$CAMPQ$	−0.027110	0.017056[0.127]	−0.034402	0.032987[0.309]
Q^1_t	−6.2682	3.9049[0.123]	3.2820	7.5521[0.668]
Q^2_t	−23.6751	6.5722[0.002]	−9.2193	12.7105[0.476]
Q^3_t	−5.5199	6.4667[0.403]	−11.3850	12.5064[0.373]
R^2	0.76796		0.43712	

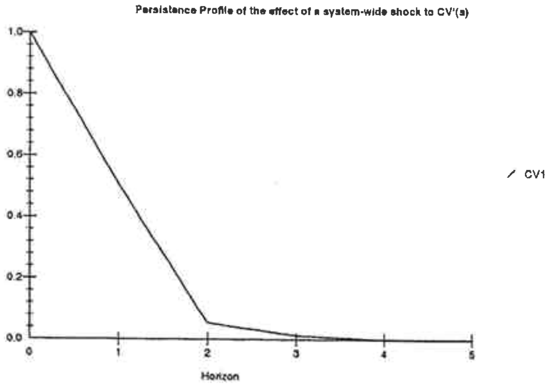

Figure 4.3: Persistence profile of the cointegrating vector in post-trade VEC model

in the instantaneous adjustment of buyer and seller prices towards the realised price. As shown above, non-stationarity (that is, an I(1) variable) in an econometric sense is shown to be equivalent to the instability of a first-order difference equation. As shown above, the saleyard price for baconers is non-stationary and therefore Walrasian unstable.

In the contemporary view of Walrasian stability, stability is seen in terms of prices, rather than a tâtonnement process. We can view the impulse-response of the ECM for the price equation as a measure of this stability process. Since the ECM for the price equation is not significant, this indicates that any shock will have a permanent effect, and thus in the contemporary view of Walrasian stability the domestic pig market is unstable.

From the results above, indications are that in the post trade liberalisation environment the Australian pig industry is characterised by both Marshallian and Walrasian instability.

As alluded to earlier, there has been some discussion as to the appropriate model structure in the treatment of imports with regards to seasonal integration. Analysis undertaken by IRIC [19] treated the import variables as $I(1)$ and it is therefore of interest to see whether this alternative specification has any effect on the model outcomes. The model was respecified with the import variables CAMVQ and CAMPQ treated as $I(1)$ exogenous variables.

The Johansen Maximum Likelihood test for cointegration presented in Table A.5 suggests that there is one cointegrating vector (See Table A.6). Given that there appears to be one cointegrating vector we estimate a VEC(2,1)[12] model which is presented in Table 4.4.

The results indicate that the cointegrating vector is again only significant for the retail price of pork, with the cointegrating vector being almost significant for the saleyard price for baconers (p=0.066). In this new model specification we can therefore conclude that the availability of imports has considerably weakened the domestic market relationship between domestic producer prices and production.

The original view of Walrasian stability does not change when we treat imports as $I(1)$ exogenous variables, as this view relies on the non-stationarity of producer

[12] That is, 2 lags with 1 ECM.

Table 4.4: post-trade VEC model with I(1) imports representation for pig industry

	ΔSPQ		$\Delta PPDQ$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$ [p-value]	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$ [p-value]
α_0	419.0664	205.7213[0.054]	1.01×10^7	4.59×10^7[0.828]
T	1.1381	0.82275[0.181]	12170.3	183489.4[0.948]
ΔSPQ_{t-1}	−0.14671	0.27565[0.600]	−117344.6	61475.9[0.070]
$\Delta SBFQ_{t-1}$	0.15191	0.20908[0.476]	−49812.3	46629.4[0.298]
ΔRPQ_{t-1}	−0.10394	0.38034[0.787]	15386.7	84824.3[0.858]
$\Delta PPDQ_{t-1}$	-0.1147×10^{-6}	0.1119×10^{-5}[0.919]	−0.37485	0.24956[0.148]
$\Delta CAMVQ_{t-1}$	-0.1025×10^{-4}	0.5406×10^{-5}[0.072]	0.24529	1.2058[0.841]
$\Delta CAMPQ_{t-1}$	−0.011459	0.040461[0.780]	−6125.1	9023.6[0.505]
ECM^1_{t-1}	−23.6171	12.1882[0.066]	−550829.4	2718214[0.841]
Q^1_t	−25.1284	7.4573[0.003]	−4381866	1663122[0.015]
Q^2_t	−47.1445	13.6217[0.002]	4109621	3037919[0.191]
Q^3_t	3.0841	12.1048[0.801]	−720973.7	2699618[0.792]
R^2	0.74451		0.84907	

	ΔRPQ		$\Delta SBFQ$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$ [p-value]	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$ [p-value]
α_0	622.5024	91.7486[0.000]	333.4833	219.1511[0.143]
T	2.3347	0.36693[0.000]	1.3023	0.87646[0.152]
ΔSPQ_{t-1}	−0.095993	0.12294[0.444]	−0.26915	0.29365[0.370]
$\Delta SBFQ_{t-1}$	0.36445	0.093247[0.001]	0.083747	0.22273[0.711]
ΔRPQ_{t-1}	−0.020606	0.16963[0.904]	−0.48871	0.40517[0.241]
$\Delta PPDQ_{t-1}$	0.7802×10^{-6}	0.4990×10^{-6}[.133]	0.2015×10^{-5}	0.1192×10^{-5}[.106]
$\Delta CAMVQ_{t-1}$	-0.2362×10^{-5}	0.2411×10^{-5}[.339]	0.1616×10^{-5}	0.5759×10^{-5}[.782]
$\Delta CAMPQ_{t-1}$	0.019077	0.018045[0.302]	0.025010	0.043102[0.568]
ECM^1_{t-1}	−36.5573	5.4357[0.000]	−19.7446	12.9838[0.143]
Q^1_t	−5.4340	3.3258[0.117]	2.0943	7.9441[0.795]
Q^2_t	−24.2069	6.0751[0.001]	−5.8986	14.5109[0.688]
Q^3_t	−5.4305	5.3986[0.326]	−14.0712	12.8950[0.288]
R^2	0.83136		0.37596	

prices, that is, SPQ being $I(1)$. In the contemporary view of Walrasian stability, stability is seen in terms of the stability of prices and thus we can view the ECM for the producer price equation as being indicative of this stability process[13]. The ECM for the producer price equation is non-significant, although borderline, indicating that at best there is weak evidence of Walrasian stability in the contemporary view.

The original view of Marshallian stability relies on the existence of a significant cointegrating vector linking prices and output. Since the cointegrating vector is only significant for retail prices, with weak evidence of a relationship with producer prices, there is only weak evidence of Marshallian stability in the original sense. In the contemporary view the ECM is non-significant for the domestic production equation and thus there is no evidence of Marshallian stability in the conventional sense.

5. Conclusions

Australia has been at the forefront of calls for a freer international trading environment, both in multilateral and bilateral forums. In doing so the gains from trade have been highlighted as the rewards for lowering barriers to trade. These claims have relied on modelling work, usually of a general equilibrium nature, showing large gains from the removal of trade barriers. Most of these models have rather restrictive assumptions, such as perfect competition and constant returns to scale which, while enabling the model to be tractable, results in outcomes which may or may not hold in reality.

The burgeoning literature on trade under imperfect competition suggests that when factor market distortions, oligopolistic firms and scale economies are taken into consideration the results are not so clear cut, and that gains from trade may or may not eventuate under these domestic distortions. At this point we are at pains to emphasize that this is not an argument for protection under the theory of the second best but rather an argument for the removal of the domestic distortion.

Factor market distortions and scale economies may result in perverse Stolper-Samuelson and Rybczynski effects which disappear if the market is characterised by Marshallian stability. Further, the resulting equilibrium from comparative static simulations is stable under Samuelson's Global Correspondence Principle if and only if the market is Marshallian stable.

In this paper we have examined the market dynamics of the Australian pig industry to determine whether or not the comparative static arguments for gains from trade can be applied with confidence to the Australian pig industry.

Our analysis relies on econometrically testing for market stability in a Vector Error Correction (VEC) framework. We use the persistence profile of the error correction mechanism (ECM), which shows the speed of adjustment of the market back to equilibrium, as a representation of Marshallian stability in its original meaning. The original view of Walrasian stability was the speed of adjustment of the tâtonnement process of prices. We view the (non-)stationarity of prices under a unit-root process as a representation of the (in)stability of the tâtonnement process. In the contemporary view of Marshallian and Walrasian stability the speed of adjustment of production and prices are seen as measures of stability respectively. We use the impulse-response

[13]The analysis in this paper was carried out using Microfit 4.0 [30]. In this version the impulse-response functions and persistence profiles of the ECM in the presence of $I(1)$ exogenous variables are not available.

functions of the cointegrating vectors in the individual equations as measures of this stability.

The results suggest that prior to trade liberalisation the Australian pig industry was characterised by both Marshallian and Walrasian stability in both the original and contemporary view. After trade liberalisation the market is characterised by both Marshallian and Walrasian instability, with weak evidence of Marshallian stability in its original meaning and weak evidence of Walrasian stability in its contemporary meaning (See Table 5.1).

Table 5.1: Marshallian and Walrasian stability

	Marshallian		Walrasian	
	< 1990	> 1990	< 1990	> 1990
Original view	✓	×?	✓	×
Contemporary view	✓	×	✓	×?

The weak evidence of Marshallian and Walrasian stability in the post trade liberalisation of the Australian pig industry is based on a model structure that treats imports as following a $I(1)$ process whereas the available evidence suggests that imports are in fact seasonally integrated. If one assumes seasonal integration in the model then the case for both Walrasian and Marshallian instability is stronger. If one takes the contemporary view then Marshallian instability is found irrespective of the model structure assumed and Samuelson's Global Correspondence Principle no longer holds.

The results of our analysis suggests several things. Firstly that trade liberalisation has changed the market structure of the Australian pig industry. Prior to trade liberalisation comparative static policy simulations, relying on the assumption of Marshallian stability, were still valid. After trade liberalisation the Australian pig industry appears to be characterised by Marshallian instability, indicating that comparative static policy simulations may not be valid. Consequently, in the post-reform era policy conclusions with respect to the Australian pig industry that are based on either the Stolper-Samuelson or Rybczynski theorems should be viewed with caution. In addition there is some question as to whether trade liberalisation is likely to lead to welfare gains, because of the instability of the resultant market allocation. This should not be interpreted as suggesting that trade liberalisation will not lead to gains from trade, rather that any such gains are not stable. Further, such instability is an artefact of the market structure and that the evolution of the market structure under structural adjustment may eventually result in Marshallian stability being imposed on the market. Even in the presence of Walrasian instability, due to Samuelson's Global Correspondence Principle, comparative static policy simulations will be valid so long as the market is Marshallian stable.. Since eight years have passed since the introduction of imports in the Australian pig industry it is of interest to see how longer structural adjustment of the market continues before stability is re-imposed.

A. Pre-trade and post-trade VEC model results

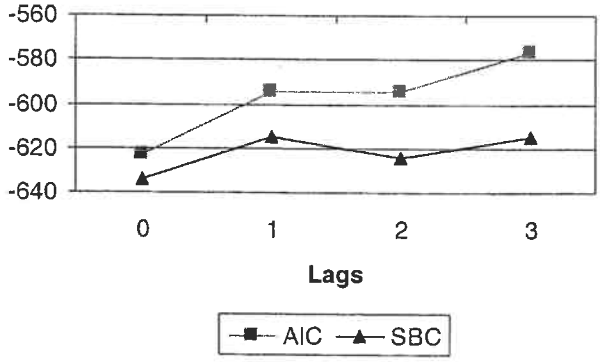

Figure A.1: AIC and SBC for pre-trade VAR model optimal lag length selection

Table A.1: Johansen ML test for Cointegration in pre-trade VEC model

H_0	H_1	Max-Eigenvalue	$\text{LR}_{Crit,0.05}$	Trace	$\text{LR}_{Crit,0.05}$	SBC_{H_1}
$r = 0$	$r = 1$	46.1148	31.0000	82.3060	58.9300	−669.8426
$r \leq 1$	$r = 2$	25.1091	24.3500	36.1912	39.3300	−665.3352
$r \leq 2$	$r = 3$	6.9599	18.3300	11.0820	23.8300	−666.6836
$r \leq 3$	$r = 4$	4.1222	11.5400	4.1222	11.5400	−666.2320

Table A.2: Cointegrating Vectors in pre-trade VEC model

	SPQ	$PPDQ$	RPQ	$SBFQ$
β_1	0.011290	0.1436×10^{-6}	−0.0094892	0.0045466
β_2	0.0062266	-0.1241×10^{-6}	−0.0084664	0.025647
$\tilde{\beta}_1$	−1.0000	-0.1272×10^{-4}	0.84051	−0.40272
$\tilde{\beta}_2$	−1.0000	0.1993×10^{-4}	1.3597	−4.1189

CI matrix $= [\beta_1, \beta_2]$

Normalised CI matrix $= \left[\tilde{\beta}_1, \tilde{\beta}_2\right]$

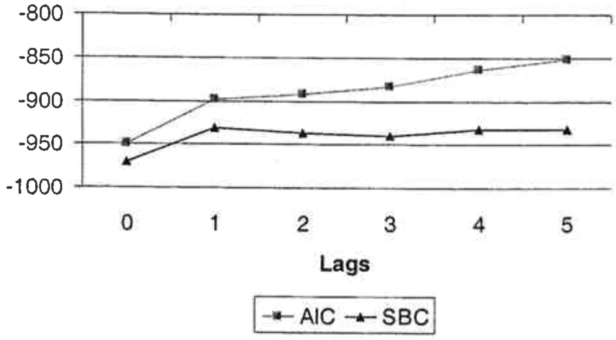

Figure A.2: AIC and SBC for post-trade VAR model optimal lag length selection

Table A.3: Johansen ML test for Cointegration in post-trade VEC model

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r=0$	$r=1$	42.6466	31.0000	71.2960	58.9300
$r\leq 1$	$r=2$	18.1228	24.3500	28.6494	39.3300
$r\leq 2$	$r=3$	9.6496	18.3300	10.5266	23.8300
$r\leq 3$	$r=4$	0.87703	11.5400	0.87703	11.5400

Table A.4: Cointegrating Vectors in post-trade VEC model

	SPQ	$PPDQ$	RPQ	$SBFQ$
β_1	−0.0074128	0.9102×10^{-7}	0.018443	−0.0012367
$\tilde{\beta}_1$	−1.0000	0.1228×10^{-4}	2.4880	−0.16683

CI matrix $= [\beta_1, \beta_2]$

Normalised CI matrix $= \left[\tilde{\beta}_1, \tilde{\beta}_2\right]$

Table A.5: Johansen ML test for Cointegration in post-trade VEC model with I(1) imports

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r=0$	$r=1$	46.2875	37.0800	87.9899	77.1400
$r\leq 1$	$r=2$	23.6481	30.9200	41.7023	53.4800
$r\leq 2$	$r=3$	14.2260	24.1800	18.0542	33.3900
$r\leq 3$	$r=4$	3.8282	17.1400	3.8282	17.1400

Table A.6: Cointegrating Vectors for post-trade VEC model with I(1) imports

	SPQ	$PPDQ$	RPQ	$SBFQ$	$CAMVQ$	$CAMPQ$
β_1	−0.0089086	0.6725×10^{-7}	0.018543	0.0015316	0.2501×10^{-7}	0.4941×10^{-3}
$\tilde{\beta}_1$	−1.0000	0.7549×10^{-5}	2.0815	0.17192	0.2808×10^{-5}	0.055464

CI matrix $= [\beta_1, \beta_2]$

Normalised CI matrix $= \left[\tilde{\beta}_1, \tilde{\beta}_2\right]$

References

[1] ABARE. various issues. *Commodity Statistical Bulletin.* Canberra: Australian Bureau of Agricultural and Resource Economics.

[2] ABARE. 1998. *Interim report on the current situation in the pig industry: Briefing note to Rural Adjustment Scheme Advisory Council. (May 1998)* Canberra: Australian Bureau of Agricultural and Resource Economics.

[3] Australian Bureau of Statistics. various issues. *ABS 7215.0 Agricultural Statistics.* Canberra: Australian Bureau of Statistics.

[4] Anderson, J. 1998. *O'Keefe reveals hypocrisy on pig industry: Media Release, Federal Minister for Primary Industries and Energy, Mr. John Anderson.* Canberra: Department of Primary Industries and Energy (11 June 1998).

[5] Anderson, J. and T. Fisher. 1998. *Government announces pig industry assistance: Joint Statement, Federal Minister for Primary Industries and Energy, Mr. John Anderson and Deputy Prime Minister and Minister for Trade, Tim Fisher.* Canberra: Department of Primary Industries and Energy (10 June 1998).

[6] Australian Pork Corporation. various issues. *PigStats, Australian Pig Industry Handbook.* Sydney: Australian Pork Corporation.

[7] Arrow, K.J., H.D. Block, and L. Hurwicz. 1959. On the stability of the competitive equilibrium, II. *Econometrica* 27.

[8] Arrow, K.J. and L. Hurwicz. 1958. On the stability of the competitive equilibrium, I. *Econometrica* 26.

[9] Comte, F. 1999. Discrete and continuous time cointegration. *Journal of Econometrics.* 88:207-226.

[10] Davies, D.G. 1963. A note on Marshallian versus Walrasian stability conditions. *The Canadian Journal of Economics and Political Science.* 29:535-540.

[11] Dickey, D. A., D.P. Hasza and W. A. Fuller. 1984. Testing for unit roots in seasonal time series. *Journal of the American Statistical Association* 79:355-367.

[12] Enders, W. 1995. *Applied econometric time series.* New York: John Wiley and Sons.

[13] Hylleberg, S., R.F. Engle, C.W.J. Granger and B.S. Yoo. 1990. Seasonal integration and cointegration. Journal of Econometrics 44:215-238.

[14] Ide, T. and A. Takayama. 1988a. Scale economies, perverse comparative statics results, the Marshallian stability and the long-run equilibrium for a small open economy. *Economics Letters.* 27:257-263.

[15] Ide, T. and A. Takayama. 1988b. Marshallian stability, long-run equilibrium and the pattern of specialization under factor-market distortions in the pure theory of international trade. *Economics Letters.* 27:265-270.

[16] Ide, T. and A. Takayama. 1990a. Marshallian stability and long-run equilibrium in the theory of international trade with factor market distortions and variables returns to scale. *Economics Letters.* 33:101-108.

[17] Ide, T. and A. Takayama. 1990b. Variable returns to scale and the Global Correspondence Principle in the theory of international trade. *Economics Letters.* 33:301-308.

[18] Inder, B. 1998. *Canadian pork imports and the Australian pigmeat market: Review of modelling reports for the Productivity Commission.* Department of Econometrics and Business Statistics, Monash University. Clayton: Monash University.

[19] Institute for Research into International Competitiveness. 1998. *Quantitative analysis of the impact of imports on the domestic pig and pigmeat industries: A report prepared for the Productivity Commission.* Institute for Research into International Competitiveness and Muresk Institute of Agriculture. Perth: Curtin University of Technology.

[20] Krugman, P.R. 1987. *Increasing returns and the theory of international trade.* In *Advances in economic theory, Fifth World Congress.* ed. T.F. Bewley 301-328. Cambridge: Cambridge University Press

[21] Krugman, P.R. 1989. *Import protection as export promotion: International competition in the presence of oligopoly and economies of scale.* In *Monopolistic competition and international trade.* ed. H. Kierzkowski 10-33. Oxford: Clarendon Press.

[22] Larue, B. 1998. *An assessment of Tim Purcell and Steve Harrison' [sic] report entitled: "The impact of trade liberalization and increasing imports on Australian pig prices".* Centre de Recherche en Economie Agroalimentaire (CREA) Université Laval, Ste-Foy, Quebec.

[23] Markusen, J.R. and J.R. Melvin. 1989. *The gains-from-trade theorem with increasing returns to scale.* In *Monopolistic competition and international trade.* ed. H. Kierzkowski 10-33. Oxford: Clarendon Press.

[24] Marshall, A. 1920. *Principles of economics: An introductory volume.* (8^{th} ed.) London: Macmillian.

[25] Neary, J.P. 1978a. Dynamic stability and the theory of factor market distortion. *American Economic Review.* 68:671-682.

[26] Neary, J.P. 1978b. Short-run capital specificity and the pure theory of international trade. *Economic Journal.* 88:488-510.

[27] Osborn, D.R., A.P.L. Chui, J.P. Smith and C.R. Birchenhall. 1988. Seasonality and the order of integration for consumption. *Oxford Bulletin of Economics and Statistics.* 50:361-377.

[28] Osborn, D.R., and P.M.M. Rodrigues. 1998. *The asymptotic distributions of seasonal unit root tests: A unifying approach.* Mimeo. School of Economic Studies, University of Manchester.

[29] Panagariya, A. 1980. Variable returns to scale in general equilibrium theory once again. *Journal of International Economics.* 10:499-526.

[30] Pesaran, M.H. and B. Pesaran. 1997. *Microfit 4.0: An interactive econometric software package.* Oxford: Oxford University Press.

[31] Pesaran, M. H. and Y. Shin. 1996. Cointegration and speed of convergence to equilibrium. Journal of econometrics. 71:117-143.

[32] Purcell, T.D. and S. Harrison. 1998. *The impact of trade liberalisation and increasing imports on the Australian pig industry: A submission to the Productivity Commission Inquiry on Pig and Pigmeat Industries: Safeguard Action Against Imports on behalf of the Department of Primary Industries, Queensland.* Brisbane: Department of Primary Industries, Queensland.

[33] Queensland Pork Producers' Organisation. 1998. *Weekly indicative prices for porkers and baconers. Unpublished dataset.* Brisbane: Queensland Pork Producers' Organisation.

[34] Takayama, A. 1974. *Mathematical economics.* Hinsdale, Illinois: Dryden Press.

[35] Newman, P. 1965. *The theory of exchange.* Englewood Cliffs, New Jersey: Prentice-Hall.

[36] Hansen, H. and K. Juselius. 1995. *CATS in RATS: Cointegration Analysis of Time Series.* Copenhagen: Institute of Economics, University of Copenhagen.

[37] Hicks, J.R. 1946. *Value and capital.* (2nd ed.). Oxford: Clarendon Press.

[38] Samuelson, P.A. 1947. *Foundations of economic analysis.* Cambridge, Massacutsetts: Harvard University Press.

[39] Stoeckel, A., D. Pearce and G. Banks. 1990. *Western trade blocks: Game set or match for Asia-Pacific and the world economy?* Canberra: Centre for International Economics.

[40] Walras, L. 1954. *Elements of pure economics.* 1926 ed. translation by W. Jaffé. London: George Allen & Unwin.

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