Farmland Ownership Policy: Technical Paper

Bell, Peter N

University of Victoria

25 January 2014

Farmland Ownership Policy: Technical Paper

Peter Bell

University of Victoria

January 25, 2014

Farmland Ownership Policy: Technical Paper

Peter Bell

Abstract: In this paper I develop a theoretical model to analyze policy that restricts who can own land. I briefly review research related to such policy in Saskatchewan, Canada, and identify a standard supply-demand model that I extend in several ways. First, I replicate results for how policy affects prices and develop new results for how policy affects social welfare using comparative statics. Second, I extend the model to a dynamic setting where demand curves change over time and show that policy can affect price changes in variety of ways, which I refer to as comparative dynamics. Third, I conduct a series of simulations to compare my model and a standard model. I establish stylistic facts about data on price levels, differences, and ratios generated by the different models.

Keywords: Farmland, ownership, policy, demand and supply, comparative statics, comparative dynamics, simulation

Introduction

This paper is written for a technical audience of mathematical economists. The results I describe provide rigour to claims made in another paper that develops a thought experiment for policy analysis (Bell, 2014). Both papers are part of my research agenda on farmland ownership. To begin, I recognize that farmland ownership is receiving much deserved attention and offer homage to the late Andro Linklater with an extended quote from his recent book, which explores land ownership as one of the most important cultural forces in human history.

> I began work on this book in 2009 as an attempt to understand the circumstances of the economic crash. A tug at the broken banking thread pulled out the political failure of regulation, and that in turn led to the Austrian school of economics, and the particular meaning that Frederich Hayek and his colleagues gave to property and liberty. Thus step by step the focus on the book turned to [land] ownership… If you concentrate on how a place is owned, however, the perspective changes. As this book demonstrates, matters of laws, of rights, and of politics become crucial, taking precedence over economics. (Linklater, 2013, p. 398-399)

The economic research literature on farmland ownership restrictions in Saskatchewan begins with Jared Carlberg (2002), an award-winning paper that Carlberg wrote during his PhD. The paper uses auction theory to predict that such policy causes lower prices because it reduces the number of bidders at auction. He uses a Present Value (PV) statistical model to test this prediction using data on average farmland prices in Saskatchewan (SK) and Alberta (AB). The model allows each province to have a change in the intercept term after the policy begins and the null hypothesis is that the intercepts are equal. Thus, the model can test if prices in SK were lower than AB after the policy. Carlberg uses a supplementary statistical approach that tests for a structural break (downward jump) in the ratio of prices (SK/AB) after the policy. Both statistical methods search for policy effects in price levels and both methods find that the policy has a statistically and economically insignificant effect on prices. This is an influential paper that led to other published papers and consulting reports on the topic, which reflects some success for Carlberg as a young academic.

Another influential paper on Saskatchewan farmland policy is written by Shon Ferguson, Hartley Furtan, and Jared Carlberg (2006). The paper uses a demand and supply model in graphical form, which I extend with further graphical analysis and an algebraic version. Ferguson et al. use the supply-demand model to perform welfare analysis and they find that the policy always causes a net social cost, which raises a puzzling question: why start the policy if it imposes a net cost on society? Ferguson et al. use the concept of endogenous policy and regulatory capture to resolve this question. They point out that, even though the policy is not in the best interest of the province, it is in the best interest of voters and politicians can exploit this for success in elections.

Although the potential for regulatory capture in farmland ownership is a serious concern, Ferguson et al. do not claim that the Province acted in bad faith because their statistical results suggest the effect of policy on prices is insignificant. Ferguson et al. use a popular statistical method known as Two Stage Least Squares to establish this result. A key variable in their theoretical model is the restrictiveness of policy, which is not observable. They use average farm size in SK to serve as a proxy for restrictiveness of policy, which "assumes that the average farm size in Saskatchewan is what the average nonresident would choose in a free market" (Ferguson et al., 2006, p. 63). As in Carlberg (2002), Ferguson et al. (2006) search for evidence of the effects of policy in price levels. However, the method in Ferguson et al. reflects progress in the literature because it allows for the effect of policy to vary over time in a non-trivial fashion.

In the final chapter of the book titled *Farmland Prices and Government Policy*, Carlberg and Furtan address the two goals of the SK policy: to cause lower prices to help new entrants and to stop the decreases to rural populations (2003, p.391). They use quasi-experimental methods similar to Carlberg (2002) and find that policy did not achieve either goal. Although this seems to be a clear conclusion, other chapters in the book show that economic research on farmland prices is notoriously controversial. For example, Philip Raup (2003) provides a careful historical account of farmland as a local, disaggregated concept, which conflicts with standard economic models and government statistics that are highly aggregated. In fact, the model I present here is highly aggregated and suffers from some of Raup's criticisms. I hope to address such challenges in the future by using big data on individual transactions in farmland. In another chapter, Calum Turvey (2003) addresses the controversy around the PV model – the model generates consistent errors when tested against real farmland prices. Turvey uses the concept of a real option to augment the PV framework, which provides a way to include uncertainty into PV calculations. These chapters show that there is ongoing, active research on farmland. I encourage interested readers to consider updating results from prior research on SK policy with larger data series currently available.

In this paper I provide technical details for my theoretical model of farmland ownership policy. This model provides new insights into the welfare effects of policy and the ways that policy can impact price changes. In Section 2 I replicate familiar results from the literature and introduce a welfare measure that opens new discussion around the net effect of the policy. In Section 3 I extend my model to a dynamic setting and show that policy can impact price differences in equilibrium. In Section 4 I conduct simulation experiments to compare my model and the PV model. I show how the effect of policy can appear in price levels, differences, and ratio of treatment to control in each model. The paper also has three appendices. In the first appendix I derive an important algebraic result. The second appendix contains a series of technical diagrams that I use to explain important parts of paper visually. The third appendix is a spreadsheet that allows readers to explore how I preformed the simulations I use in Section 4.

2. Comparative Statics

The model I use is a basic demand and supply model for market equilibrium. The model applies to any situation where one group of buyers is forbidden from participating in a market. Thus, the building blocks for the model are the downward-sloping demand functions for two groups: domestic buyers ($Q^D(P)$) and foreign buyers ($Q^F(P)$). I assume the supply is perfectly inelastic (constant) for all prices, which I denote it as $\widetilde{Q}$. I solve market equilibrium based on total demand and supply. In an open market, total demand is sum of domestic and foreign demand ($Q^O(P)$) as in Equation (2.1), which economists refer to as a horizontal sum of demand (Ferguson et al., 2006, p. 61). The total demand in a closed market (Q^C) is just domestic demand, Equation (2.2).

$$Q^O(P) = Q^D(P) + Q^F(P) \tag{2.1}$$

$$Q^C(P) = Q^D(P) \tag{2.2}$$

To solve the market clearing price, I use total demand and supply. I start with domestic and foreign demand, combine them, and then solve equilibrium prices. This adds an extra step compared with solving equilibrium prices in a model with one demand curve, where I can solve prices using the inverse demand function. The inverse demand for total demand in an open market ($Q^O(P)$) may not be continuously differentiable (it may be defined piecewise). This extra step in my model introduces a risk that the mathematical model produces economically unrealistic results, such as negative quantity demand for certain prices. Therefore, I am careful in my analysis to check equilibrium conditions and avoid such a scenario. I denote prices as $P^O: Q^O(P^O) = \tilde{Q}$ for an open market and $P^C: Q^C(P^C) = \tilde{Q}$ for a closed market.

Result 1: Policy causes lower prices ($P^O > P^C$).

Proof: I use a proof by contradiction. Suppose $P^O < P^C$. Then $Q^O(P^C) = \overline{Q} + Q^F(P^C) > \overline{Q}$ because $Q^F(P) > 0$. But $P^O < P^C$ implies that $Q^O(P^O) > Q^O(P^C)$ because $\frac{dQ^O}{dP} < 0$. It follows that $Q^O(P^O) > \overline{Q}$, which is a contradiction. □

Next I develop analysis for the effect of policy on social welfare. As in in Equations (2.3) and (2.4), I denote $CS^{D,O}$ as the consumer surplus for domestic demand in an open market and $CS^{F,O}$. In contrast to the proof for Result 1, I assume that there is a cut-off price where quantity of demand for each group goes to zero. I denote these prices as $\overline{P^D}: Q^D\left(\overline{P^D}\right) = 0$ and $\overline{P^F}: Q^F\left(\overline{P^F}\right) = 0$.

(2.3) $CS^{D,O} = \int_{P^O}^{\overline{P^D}} Q^D\,(p)dp$

(2.4) $CS^{F,O} = \int_{P^O}^{\overline{P^F}} Q^F\,(p)dp$

Definition of consumer surplus for domestic and foreign buyers in closed market given in Equation (2.5) and (2.6). Notice that foreigners generate zero consumer surplus in closed market because not allowed to participate.

(2.5) $CS^{D,C} = \int_{P^C}^{\overline{P^D}} Q^D\,(p)dp$

(2.6) $CS^{F,C} = 0$

A careful reader will notice that I use integrals over price (dp) here rather than quantity (dq). Standard analysis often uses quantity-integrals with inverse demand functions but the price integrals are better suited to my analysis because I am using demand functions.

Result 2: Policy increases welfare for domestic buyers and decreases welfare for foreign.

Proof: I use a proof by construction. First, I show that policy benefit domestic demand. $\mathrm{CS}^{\mathrm{D,O}} - \mathrm{CS}^{\mathrm{D,C}} = \int_{\mathrm{pc}}^{\overline{\mathrm{PD}}} \mathrm{Q^D}\,(\mathrm{p})\mathrm{dp} - \int_{\mathrm{po}}^{\overline{\mathrm{PD}}} \mathrm{Q^D}\,(\mathrm{p})\mathrm{dp} = \int_{\mathrm{pc}}^{\mathrm{P^O}} \mathrm{Q^D}\,(\mathrm{p})\mathrm{dp}$. And $\int_{\mathrm{pc}}^{\mathrm{P^O}} \mathrm{Q^D}\,(\mathrm{p})\mathrm{dp} > 0$ because $\mathrm{P^O} > \mathrm{P^C}$ and $\mathrm{Q^D}(\mathrm{p}) > 0\ \forall \mathrm{p}$.

Second, I show that policy hurt foreign demand. $\mathrm{CS}^{\mathrm{F,C}} - \mathrm{CS}^{\mathrm{F,C}} = -\int_{\mathrm{pc}}^{\overline{\mathrm{PF}}} \mathrm{Q^F}\,(\mathrm{p})\mathrm{dp}$. And $-\int_{\mathrm{pc}}^{\overline{\mathrm{PF}}} \mathrm{Q^F}\,(\mathrm{p})\mathrm{dp} < 0$ because $\overline{\mathrm{P^F}} > \mathrm{P^O}$ and $\mathrm{Q^F}(\mathrm{p}) > 0\ \forall \mathrm{p}$. □

In a companion paper, I develop a hypothetical case for SK policy based on a Net Benefit Test that I describe as follows "*the policy passes the Net Benefit Test when domestic demand is larger than foreign; the policy fails the Test when foreign demand is larger than domestic*" (Bell, 2014, p. 5). This Test is based on the change in the welfare measure I describe below. The welfare measure is defined by Equation (2.7), it has index I that denotes an open market ($\mathrm{I} = \mathrm{O}$) or a closed one ($\mathrm{I} = \mathrm{C}$). The effect of the policy on welfare is defined by Equation (2.8) and my Net Benefit Test is based on the sign of $\Delta\mathrm{W}$: when $\Delta\mathrm{W} > 0$ the policy passes Net Benefit Test and when $\Delta\mathrm{W} < 0$ the policy fails the Test.

(2.7) $\mathrm{W^I} = \mathrm{CS}^{\mathrm{D,I}} + \mathrm{CS}^{\mathrm{F,I}}$

(2.8) $\Delta\mathrm{W} = \mathrm{W^C} - \mathrm{W^O}$

My welfare measure is different from Ferguson et al. (2006) because I exclude producer surplus. I exclude it because no-one makes farmland, so no-one creates producer surplus. We can count the surplus associated with supplying farmland as a resource rent, but then the welfare measure suggests the policy always imposes a net cost on society. My measure finds that policy can have net benefit or cost, depending on conditions, which is useful from a modelling perspective because it provides new way to analyze the policy. However, this discussion is part of a much broader dialogue around how to model farmland within a neoclassical economic framework – see further discussion in the book *Farmland Prices and Government Policy*.

$$(2.9) \qquad \Delta W = \left(\frac{(\bar{Q}+a^D-a^F)(\bar{Q}-a^D+a^F)}{4b} \right)$$

Equation (2.9) is an explicit result for the Net Benefit Test derived under simplified conditions. The derivation is provided in an appendix. In simple terms, the proof assumes linear demand curves with same slope in domestic and foreign but different intercept terms. Again, the result has to be used carefully to avoid making unrealistic intermediary results. I use Equation (2.9) to establish that policy can have net benefit when domestic demand larger than foreign demand, which is an important part of my Net Benefit Test.

Result 3: Policy has net benefit when domestic demand larger than foreign ($\Delta W > 0 \leftrightarrow Q^D(p) > Q^F(p)\ \forall p$.

Proof: I use a proof by construction. I assume linear demands with equal slopes. When I say domestic demand is larger than foreign, this means $a^D > a^F$ within my model. This implies that $(\bar{Q} + a^D - a^F) > 0$, which ensures the first term in Equation (2.9) is positive.
To ensure that the second term in Equation (2.9) is positive, I assume that supply satisfies conditions that mean domestic and foreign demand are both positive in equilibrium ($a^D - a^F < \bar{Q} < a^D + a^F$). The lower bound on $\bar{Q}$ implies that $a^D < \bar{Q} + a^F$ and $0 < \bar{Q} - a^D + a^F$, which is the second term in Equation (2.9).
Since each term in (2.9) is positive, $\Delta W > 0$ and the policy has a net benefit. Note: I provide a graphical description of this result in Figure 2 of the graphical appendix. □

Result 4: Policy has net cost when foreign demand is larger than domestic.

Proof: I demonstrate this result in Figure 2 of the graphical appendix.

Results 3 and 4 give technical evidence to support my claim that the policy has a net benefit when domestic demand is larger than foreign and a net cost when foreign demand is larger than domestic. Furthermore, the results allow me to refine my language around the Test. According to my graphical example of Result 4, the policy has a net cost when foreign demand is larger at all prices *and* more inelastic to price changes than domestic demand. To see this inelasticity, look to the bottom pane of Figure 2: the dashed line is steeper than the solid line at the constant quantity of supply. According to my analytic proof of Result 3, the policy has a net cost when domestic demand is larger at all prices. I do not need the extra assumption of inelasticity to establish Result 3 because it is an easier result within my model.

3. Comparative Dynamics

To develop further results, I assume the demand curves are linear. I allow domestic and foreign demand curves to differ based on the total size of demand (a^D, a^F) but not their marginal behaviour or elasticity (b). However, the assumptions are helpful for analyzing how policy affects price changes.

$$Q^D(P) = a^D - bP \tag{3.1}$$

$$Q^F(P) = a^F - bP \tag{3.2}$$

The equilibrium prices in open and closed markets are given in Equations (3.3) and (3.4).

$$P^O = \frac{1}{2b}(a^D + a^F - \widetilde{Q}) \tag{3.3}$$

$$P^C = \frac{1}{b}(a^D - \widetilde{Q}) \tag{3.4}$$

To analyze price changes, I allow the intercepts to change over time. I introduce this assumption in Equation (3.5) and (3.6). This allows me to compare price changes in an open and closed market, which I refer to as comparative dynamics in reference to the classic technique known as comparative statics.

(3.5) $$P = f(a^D(t), a^F(t), b)$$

(3.6) $$\frac{dP}{dt} = \frac{df}{da^D}\frac{da^D}{dt} + \frac{df}{da^F}\frac{da^F}{dt}$$

Equation (3.6) provides a new insight that I discuss further in Figure 3 of the graphical appendix. Basically, price changes in an open market are driven by two factors whereas they are only driven by one factor in a closed market. The relative sizes of the two factors determines the difference between price changes in an open and closed market.

To make the price changes explicit, I calculate the derivatives of equilibrium prices in Equations (3.3) and (3.4). The price changes for an open market and closed market are given in Equation (3.7) and (3.8).

(3.7) $$\frac{dP^O}{dt} = \frac{1}{2b}\left(\frac{da^D}{dt} + \frac{da^F}{dt}\right)$$

(3.8) $$\frac{dP^C}{dt} = \frac{1}{b}\left(\frac{da^D}{dt}\right)$$

I combine the two equations for price changes to create a new term: the difference in differences. This single term is defined in Equation (3.9). It describes how policy affects the price changes – it is the gap between the growth rates in an open and closed market. When the gap is positive, the closed market is becoming underpriced relative to the open market. Hence, it is useful for assessing the basic research question: does the policy cause lower prices?

(3.9) $$\frac{dP^O}{dt} - \frac{dP^C}{dt} = \frac{1}{2b}\left(\frac{da^D}{dt} - \frac{da^F}{dt}\right)$$

In Figure 4 of the graphical appendix I discuss eight different ways that policy can affect prices changes. The policy can cause prices in the closed market to lag behind the open one or to accelerate ahead, either in a bull or a bear market. This is a bold new set of results that can advance the literature on this topic. However, the results have a possible weakness because they can generate almost any type of behaviour. The results do not have stark, testable predictions; rather, they can account for any type of market action.

In order to make my results described in Figure 4 operational, I focus on two types of behaviour: shift and dampen. I created the name for each myself based on the intuition behind them. The *shift effect* refers to a situation where price changes are lower in a closed market than an open market: the policy causes price changes to shift downwards. This implies that the difference in differences will be positive and price levels in the closed market will be lower. The shift effect is related to Carlberg's (2002) idea that policy causes lower prices, but it is articulated in terms of price changes rather than price levels.

The *dampen effect* refers to a situation where price changes in a closed market are smaller in absolute value than an open market. Price changes in an open and closed market always have the same sign, but the closed region is always smaller in absolute value. In this case the difference in differences can be positive or negative. The dampen effect can be described as a situation where policy reduces sensitivity (beta) of farmland prices to some fundamental risk factor that drives prices.

4. Simulation Experiments

In this section I compare different types of data generated by my model and the standard PV model. First I specify the models and then discuss simulations of price levels, differences, and ratios. Each model allows me to control how data is generated separately for open and closed markets, before and after the policy starts. I use the simulations to establish stylized facts about the types of behaviour that each model can generate.

I begin with the standard PV model described by Carlberg (2002). The model is expressed in terms of price levels and allows for a change in the intercepts after the policy starts. I describe the model using my own notation in Equations (4.1) to (4.4).

$$P^{O,B,T} = \alpha^{T} + \varepsilon^{O,T} \quad (4.1)$$

$$P^{C,B,T} = \alpha^{T} + \varepsilon^{C,T} \quad (4.2)$$

$$P^{O,A,T} = \alpha^{T} + \varepsilon^{O,T} \quad (4.3)$$

(4.4) $P^{C,A,T} = \alpha^{T} - \delta + \varepsilon^{C,T}$

Since I use my own notation here, I discuss the variables in detail. The price levels $P^{I,J,K}$ have three superscripts: I denotes region, O for open, C for closed; J denotes whether policy has started or not, B for before policy, A for after policy; and K denotes time. I denote the trend for price levels as α^{T}; I assume the open and closed market have the same trend to make the experimental set up clean (only difference is presence of policy). I allow each region to have separate noise term, denoted $\varepsilon^{O,T}$ for open region and $\varepsilon^{C,T}$ for closed. The noise can have an arbitrary structure, but I pick uniform distribution with low volatility because it produces stationary first differences – an important assumption for PV model.

The key idea of Carlberg (2002) is that policy causes lower prices. I build this idea into the model with a dummy variable in the intercept for the closed region after the policy, which is δ in Equation (4.4). Since the dummy is positive ($\delta > 0$), the average price in the policy region jumps downwards after the policy starts. Technically, Carlberg allows each region to have a separate dummy after the policy starts but I assume the open region has zero jump to make the experiment clean (only difference is presence of policy). It is possible to conduct further simulations in this vein in order to explore statistical power of the regression method.

The results of simulation using Carlberg's model are provided in Figure 5 of the graphic appendix. The simulation is meant to resemble situation where prices have an increasing trend, low levels of noise, and a large drop in prices after the start of policy. Details on the simulation are provided in the spreadsheet appendix. There are several important things to recognize about the simulations. First, the policy has a one-time, permanent effect on price levels. Second, the policy effect appears as an outlier in price differences – a very large price decrease in the period when the policy starts. Third, the ratio of prices drops after policy and then normalizes slowly (prices have an increasing trend, so the size of the jump caused by policy becomes relatively smaller over time). This set of facts is familiar in a hyper-rational economic framework where agents can discount the future into the single instant when the change happens, it is a useful baseline to show how policy can affect equilibrium prices.

Next I discuss my model. The order of operation in my simulations is different from Carlberg's model because I start with price differences, then calculate price levels and the ratio.

With Carlberg's model, I started with price levels and then calculate price differences and the ratio. The intuition for my model is that open and closed markets have the same trend growth rates before the policy (cointegration) but not after the policy. After the policy, the closed region is different somehow – I make this statement precise using the shift and dampen effects.

The first case I present with my model is the shift effect. Recall that shift means that policy causes price changes to be lower than they would otherwise. I describe this model in Equations (4.5)—(4.8).

(4.5) $$\frac{dP^{O,B,T}}{dt} = \alpha^{T} + \varepsilon^{O,T}$$

(4.6) $$\frac{dP^{C,B,T}}{dt} = \alpha^{T} + \varepsilon^{C,T}$$

(4.7) $$\frac{dP^{O,A,T}}{dt} = \alpha^{T} + \varepsilon^{O,T}$$

(4.8) $$\frac{dP^{C,A,T}}{dt} = \alpha^{T} - \delta + \varepsilon^{C,T}$$

I denote price differences as $\frac{dP^{I,J,K}}{dt}$ where superscripts have same meaning as before (region indicator, policy indicator, time index). I assume the open and closed market both have the same trend growth rates, denoted α^{T}. I allow each region to have a separate noise term, denoted $\varepsilon^{O,T}$ for open region and $\varepsilon^{C,T}$ for closed. Again, I assume the noise have a uniform distribution with low volatility. The shift effect means that price changes are lower for the closed market after the policy, which I build into the model with a change in the intercept for the closed market after the policy begins, the δ in Equation (4.8) ($\delta > 0$).

Results of my simulation using the shift effect are described in Figure 6 of the graphical appendix. Again, the simulation is meant to represent a bull market where the policy causes lower price changes and details are provided in the appendix. First, notice that policy marks a break point where price levels in the open and closed market diverge. They diverge at an instant and head away from each other for the remainder of the simulation. Second, there is also a break point seen in the price differences: after the policy starts, price changes in the closed market are lower than the open one (by construction). Third, the price ratio has a break point at the policy start date. After the policy starts, the ratio trends downward over the entire simulation. These three observations are very different from the simulations with Carlberg's model. My model shows the ability to produce prices where the effect of policy grows larger over time, which is a new stylized facts for the literature.

The second case I present with my model is the dampen effect. Recall that the dampen effect means that policy decreases the absolute value of price changes. The equations for price changes in this model are the same as the shift case, except for the closed region after the policy. Therefore, I replace Equation (4.8) with (4.9). For my simulations with the dampen effect, the trend growth rate (α^T) in the closed region is a fraction of the growth rate in the open region. This fraction ($0 < \delta < 1$) makes it so that price changes in the closed region have the same sign as the open region but are smaller in absolute value.

$$\text{(4.9)} \qquad \frac{dP^{C,A,T}}{dt} = \delta\, \alpha^T + \varepsilon^{C,T}$$

Results of my simulation using the dampen effect are described in Figure 7 of the graphical appendix. This time the simulations are meant to represent a bear market, where prices steadily fall. I picked this scenario to show that policy can cause *higher prices*. First, notice that policy marks break a point in price levels. After the policy starts, prices in closed market fall less quickly than the open market; dampening price changes during a bear market means less price decreases. Second, there is clear evidence that price changes in the closed market are smaller than the open market after the policy begins (by construction). Third, the price ratio actually increases over time. Again, simulations from my model produce a series of new insights for the literature.

5. Conclusion

In this paper I use an old model to generate a new set of results. The model is a classic one for general equilibrium with multiple sources of demand and supply. The new results show how the policy can have a net benefit or net cost depending on all demand curves depending on the relative sizes of those who are allowed in or excluded from the market by government policy.

One important result for my research agenda is the existence of the conditions for my Net Benefit Test. I show that the policy has a net benefit when domestic demand is larger than foreign demand and the policy has a net cost when foreign demand is larger (and more inelastic) than domestic demand. I prove the net benefit result under general conditions using a technical result derived in an appendix to this paper. I demonstrate the net cost result using graphical analysis in Figure 2 of the graphical appendix. These results need further development before they should be used for government policy, but they provide evidence to support my analysis that suggests policy changes may be related to increasing activity from farmland investment funds in SK (Bell, 2014).

Another important result for my research agenda is the fact that policy can affect price changes. My theoretical model provides new insights that go beyond the conventional claim: policy causes lower prices (Carlberg, 2002). In my model, policy affects price changes in a way that accumulates over time, unlike the standard model that requires an instantaneous adjustment. The policy can cause several different types of effects in my model, which leads me to introduce the shift and dampen effects to build structure into my model. Going forward, I will be careful to keep “gentlemanly distance” between my assumptions and results.

The next stages of my modelling will comprise empirical applications of my model. To begin, I compare the standard PV model and my new model in simulation. Simulation provides a way to analyze a model in an almost visceral manner – we see examples of paths of data that can be generated by the models and can compare between them. This is not yet a formalized statistical procedure, but it is useful for establishing stylized facts. I simulate price levels, differences, and ratio of open to closed prices for the standard model and my model with either the shift or dampen effect. For the standard model, the policy has a one-time effect on prices, which stands out as an outlier in price changes. The policy causes an instant jump in the price ratio, which shrinks over time as prices increase. In contrast, my model produces large and persistent effects on price levels, differences, and the ratio. I show that the price ratio can decrease or increase in different cases, which is contrary to an important assumption in prior research (for example: Carlberg & Furtan, 2003, p. 392). Although I have not included results of estimation, it is possible to reconcile my simulation framework with the estimation framework used by prior researchers and generate conventional estimates of policy effects with my model.

References

Bell, P.N. (2014). *Farmland Ownership Restrictions: Between a Rock and a Hard Place*. Unpublished manuscript, Department of Economics, University of Victoria, Victoria, Canada. Retrieved from http://mpra.ub.uni-muenchen.de/53033/

Carlberg, J.G. (2002). Effects of Ownership Restrictions on Farmland Values in Saskatchewan. *Journal of Agricultural and Applied Economics, 34*(2), 349—358.

Carlberg, J. & Furtan, H. (2003). Effects of Government Restrictions on Land Ownership: The Saskatchewan Case. In C. Moss & A. Schmitz (Eds.), *Government Policy and Farmland Markets* (pp. 391—406). Ames, IA: Iowa State Press.

Ferguson, S., Furtan, H., & Carlberg, J. (2006). The Political Economy of Farmland Ownership Regulations and Land Prices. *Agricultural Economics, 35*, 59—65.

Linklater, A. (2013). *Owning the Earth: The Transforming History of Land Ownership*. New York, NY: Bloomsbury USA.

Raup, P.M. (2003). Disaggregating Farmland Markets. In C. Moss & A. Schmitz (Eds.), *Government Policy and Farmland Markets* (pp.15—26). Ames, IA: Iowa State Press.

Turvey, C. (2003). Hysteresis and the Value of Farmland: A Real-Options Approach to Farmland Valuation. In C. Moss & A. Schmitz (Eds.), *Government Policy and Farmland Markets* (pp.179—208). Ames, IA: Iowa State Press.

Appendix to Farmland Ownership Policy Paper:

Proof of Welfare Result

Peter Bell

In this appendix, I provide derivation of result: $\Delta W = \left(\frac{(\bar{Q}+a^D-a^F)(\bar{Q}-a^D+a^F)}{4b}\right)$. I use this result to establish that the policy has a net benefit when domestic demand is larger than foreign demand.

To begin, I provide definitions for the terms involved in the social welfare calculations.

1. $\overline{P^D}: Q^D\left(\overline{P^D}\right) = 0,\ \overline{P^F}: Q^F\left(\overline{P^F}\right) = 0$
2. $\Delta CS^D = CS^{D,C} - CS^{D,O} = \int_{pc}^{\overline{PD}} Q^D\,(p)dp - \int_{po}^{\overline{PD}} Q^D\,(p)dp = \int_{pc}^{P^O} Q^D\,(p)dp$
3. $\Delta CS^F = CS^{F,C} - CS^{F,O} = 0 - \int_{pc}^{\overline{PF}} Q^F\,(p)dp$
4. $W^I = CS^{D,I} + CS^{F,I}\ for\ \mathrm{I = C\ or\ O}$
5. $\Delta W = W^C - W^O = \Delta CS^D + \Delta CS^F$
6. $\Delta W = \int_{pc}^{P^O} Q^D\,(p)dp - \int_{pc}^{\overline{PF}} Q^F\,(p)dp$

I establish the proof under specific assumptions about the demand curves (both are linear with same slopes). These are reflected in the following results concerning market outcomes.

7. $Q^D(P) = a^D - bP$
8. $Q^F(P) = a^F - bP$
9. $P^C = \frac{a^D-\bar{Q}}{b}$ denotes price in a closed market
10. $P^O = \frac{a^D+a^F-\bar{Q}}{2b}$ denotes price in an open market
11. $\overline{P^F} = \frac{a^F}{b}$ denotes price that drives foreign demand to zero

Over the next few equations, I derive a formula for the change in domestic welfare caused by policy.

12. $\Delta CS^D = \int_{pc}^{P^O} Q^D\,(p)dp$
13. $\ldots = a^D P - \frac{b}{2}P^2\,\Big|_{pc}^{P^O}$

14. $\ldots = a^D\left(\frac{a^D+a^F-\bar{Q}}{2b}-\frac{a^D-\bar{Q}}{b}\right)-\frac{b}{2}\left[\left(\frac{a^D+a^F-\bar{Q}}{2b}\right)^2-\left(\frac{a^D-\bar{Q}}{b}\right)^2\right]$
15. $\ldots = a^D\left(\frac{a^F+\bar{Q}-a^D}{2b}\right)-\frac{b}{2}\left[\frac{(a^D)^2+(a^F)^2+(\bar{Q})^2+2a^Da^F-2a^D\bar{Q}-2a^F\bar{Q}}{4b^2}-\frac{(a^D)^2+(\bar{Q})^2-2a^D\bar{Q}}{b^2}\right]$
16. $\ldots = \left(\frac{a^Da^F+a^D\bar{Q}-(a^D)^2}{2b}\right)-\frac{1}{8b}\left[(a^D)^2+(a^F)^2+(\bar{Q})^2+2a^Da^F-2a^D\bar{Q}-2a^F\bar{Q}-4(a^D)^2-4(\bar{Q})^2+8a^D\bar{Q}\right]$
17. $\ldots = \left(\frac{4a^Da^F+4a^D\bar{Q}-4(a^D)^2}{8b}\right)-\frac{1}{8b}\left[(a^F)^2-3(a^D)^2-3(\bar{Q})^2+2a^Da^F+6a^D\bar{Q}-2a^F\bar{Q}\right]$
18. $\ldots = \left(\frac{2a^Da^F-2a^D\bar{Q}-(a^D)^2-(a^F)^2+3(\bar{Q})^2+2a^F\bar{Q}}{8b}\right)$

Over the next few equations, I derive a formula for the change in foreign welfare caused by policy.

19. $-\Delta CS^F = \int_{P^O}^{\overline{P^F}} Q^F(p)dp$
20. $\ldots = a^FP-\frac{b}{2}P^2 \,\Big|_{P^O}^{\overline{P^F}}$
21. $\ldots = a^F\left(\frac{2a^F-a^D-a^F+\bar{Q}}{2b}\right)-\frac{b}{2}\left[\left(\frac{a^F}{b}\right)^2-\left(\frac{a^D+a^F-\bar{Q}}{2b}\right)^2\right]$
22. $\ldots = a^F\left(\frac{a^F+\bar{Q}-a^D}{2b}\right)-\frac{b}{2}\left[\left(\frac{4(a^F)^2}{4b^2}\right)-\left(\frac{(a^D)^2+(a^F)^2+(\bar{Q})^2+2a^Da^F-2a^F\bar{Q}-2a^D\bar{Q}}{4b^2}\right)\right]$
23. $\ldots = \left(\frac{4(a^F)^2+4a^F\bar{Q}-4a^Da^F}{8b}\right)-\frac{\left(3(a^F)^2-(a^D)^2-(\bar{Q})^2-2a^Da^F+2a^F\bar{Q}+2a^D\bar{Q}\right)}{8b}$
24. $\ldots = \frac{(a^F)^2+2a^F\bar{Q}-2a^Da^F+(a^D)^2+(\bar{Q})^2-2a^D\bar{Q}}{8b}$

It follows that:

25. $\Delta CS^D+\Delta CS^F = \left(\frac{2a^Da^F-2a^D\bar{Q}-(a^D)^2-(a^F)^2+3(\bar{Q})^2+2a^F\bar{Q}}{8b}\right)-\left(\frac{(a^F)^2+2a^F\bar{Q}-2a^Da^F+(a^D)^2+(\bar{Q})^2-2a^D\bar{Q}}{8b}\right)$
26. $\ldots = \left(\frac{4a^Da^F-2(a^D)^2-2(a^F)^2+2(\bar{Q})^2}{8b}\right)$
27. $\ldots = \left(\frac{(\bar{Q})^2-(a^D-a^F)^2}{4b}\right)$
28. $\ldots = \left(\frac{(\bar{Q}+a^D-a^F)(\bar{Q}-a^D+a^F)}{4b}\right)$

This establishes the intended result.

29. $\Delta W = \Delta CS^D+\Delta CS^F = \left(\frac{(\bar{Q}+a^D-a^F)(\bar{Q}-a^D+a^F)}{4b}\right)$ □

To conclude, I demonstrate the result with a numerical example.

I assume that $Q^D(P) = 10 - P, Q^F(P) = 5 - P, \overline{Q} = 8$. Then it follows that $P^D = 2, \overline{P^F} = 5, P^T = \frac{7}{2}$.

$$\Delta CS^D = \int_2^{7/2} 10 - P\, dp = 10P - \frac{1}{2}P^2|_2^{7/2} = 10\left(\frac{7-4}{2}\right) - \frac{1}{2}\left(\frac{49-16}{4}\right) = \left(\frac{120}{8}\right) - \left(\frac{33}{8}\right) = \frac{87}{8}$$

$$-\Delta CS^F = \int_{7/2}^{5} 5 - P\, dp = 5P - \frac{1}{2}P^2|_{7/2}^{5} = 5\left(\frac{10-7}{2}\right) - \frac{1}{2}\left(\frac{100-49}{4}\right) = \left(\frac{60}{8}\right) - \left(\frac{51}{8}\right) = \frac{9}{8}$$

So $\Delta CS^D + \Delta CS^F = \frac{87}{8} - \frac{9}{8} > 0$. This provides an example of a market where the policy has a net benefit when $Q^D(P) > Q^F(P)$.

Graphical Appendix: Farmland Ownership Policy Technical Paper

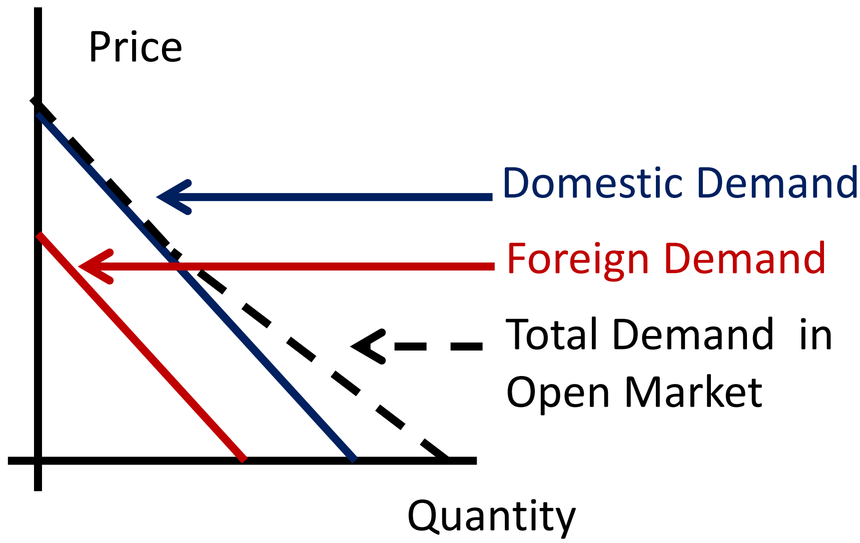
Peter Bell

University of Victoria

January 25, 2014

Figure 1: Static Effects of Policy on Prices

This diagram shows the two sources of demand in the market.



This diagram shows how the policy causes lower prices (domestic demand is larger than foreign for illustration).

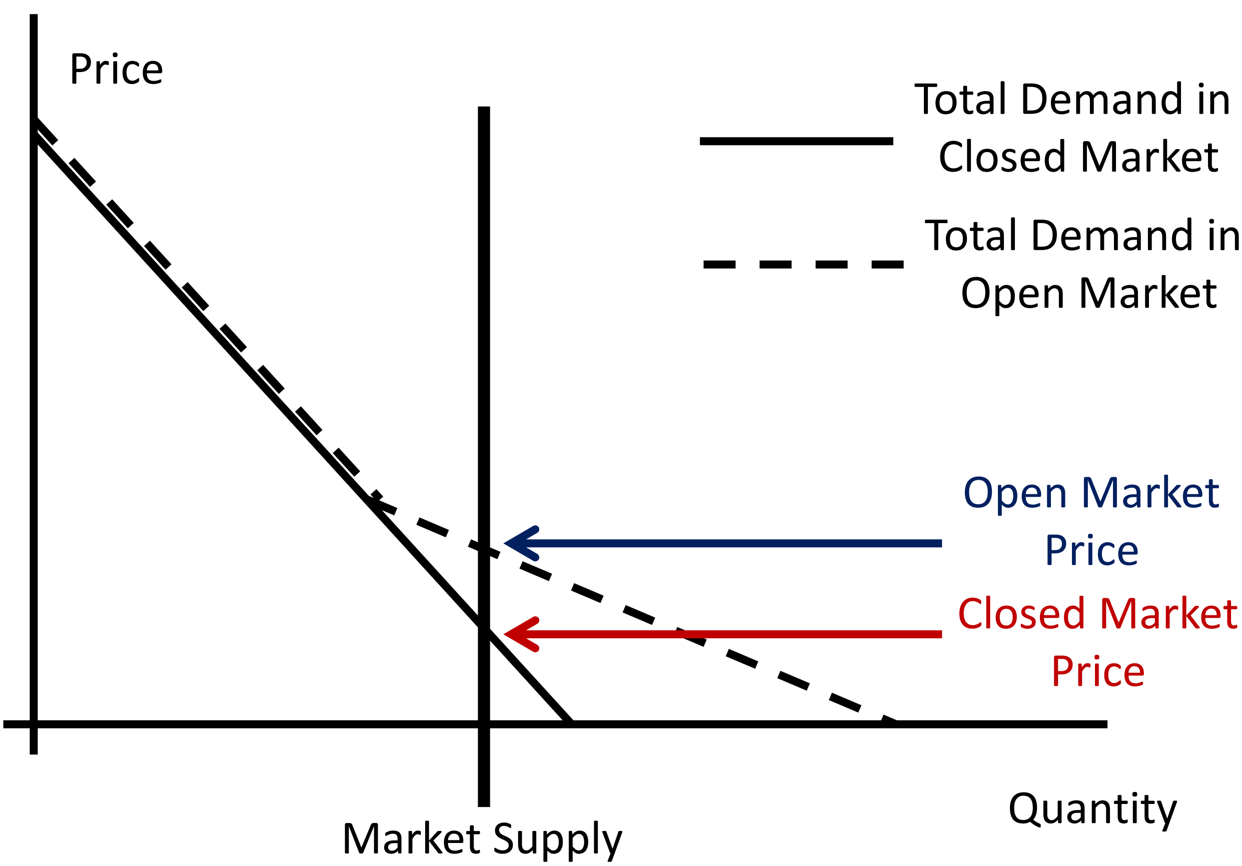
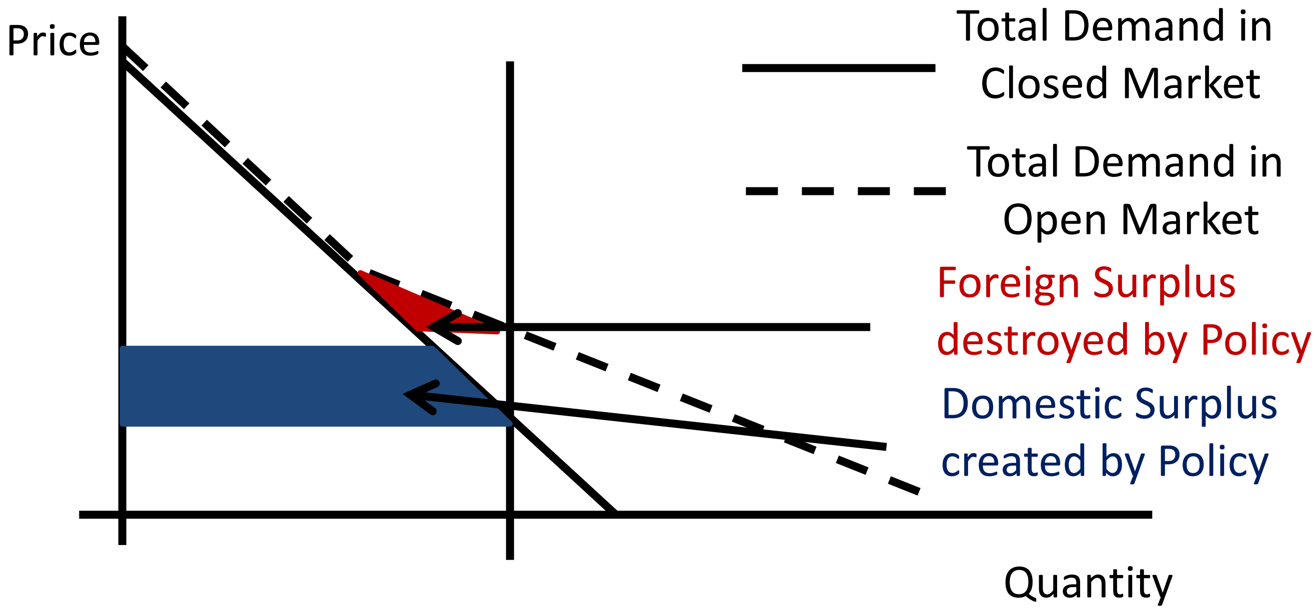


Figure 2: Welfare Effects of Policy

This diagram shows how the policy has net benefit when domestic demand is larger than foreign.



This diagram shows how the policy has net cost when foreign demand is larger than domestic.

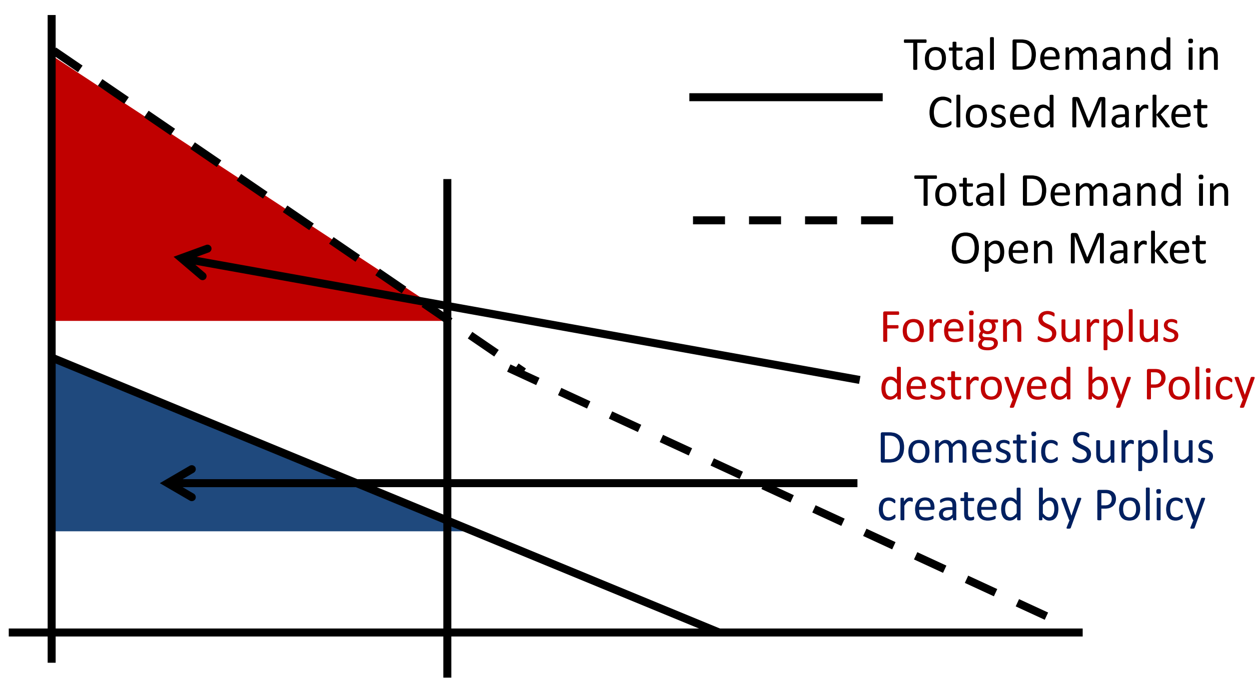
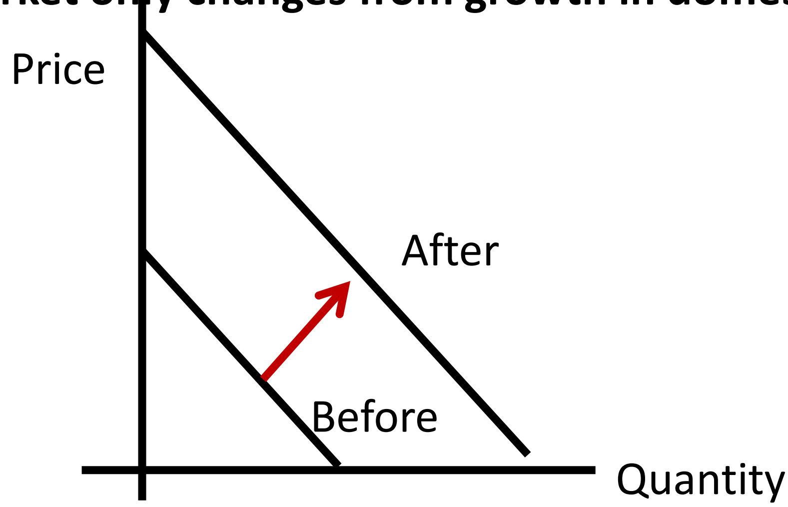


Figure 3: Effects of Policy on Price Dynamics

This diagram shows how total demand changes in a closed market.
The market only changes from growth in domestic demand.



This shows how total demand changes in an open market when foreign demand grows faster than domestic. In this case, policy reduces (dampens) the price increase.

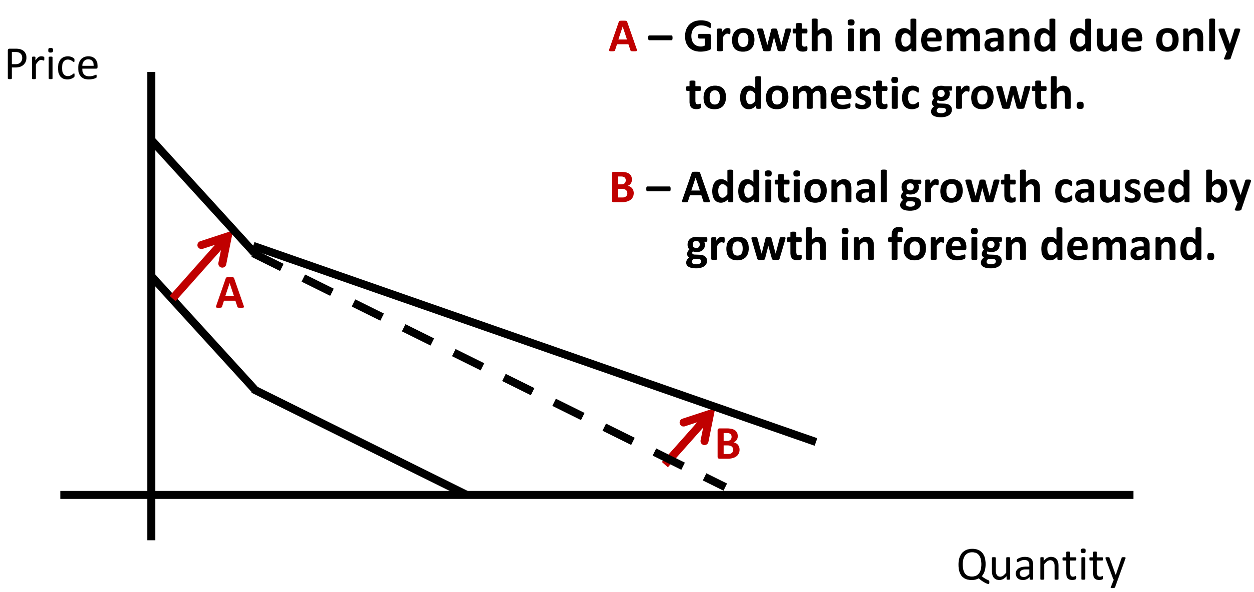
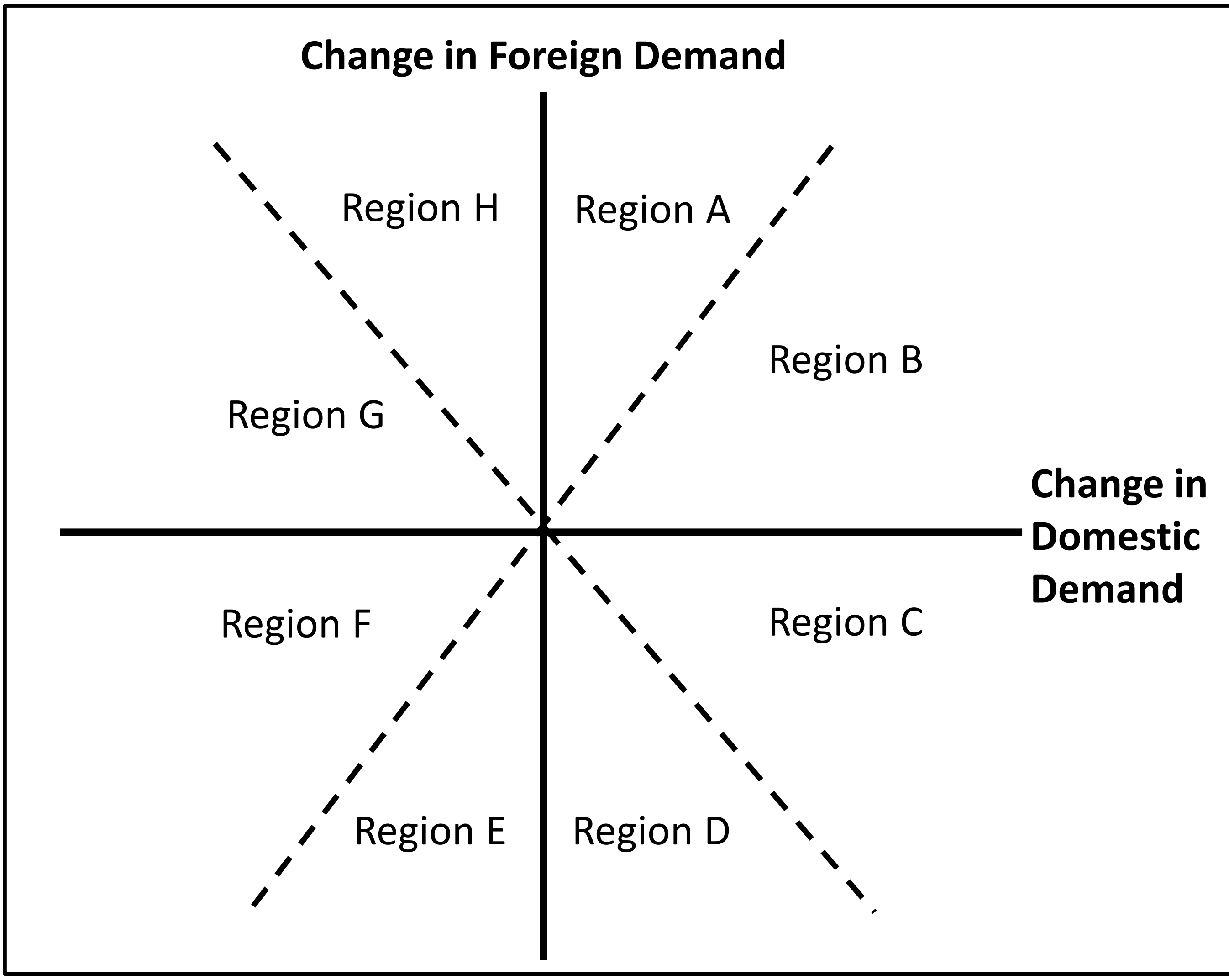
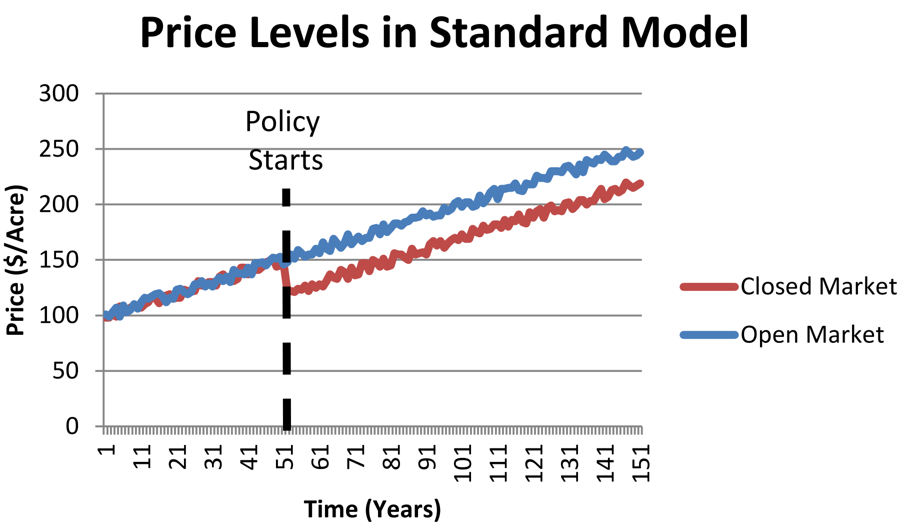


Figure 4: Different Ways Policy can affect Price Changes

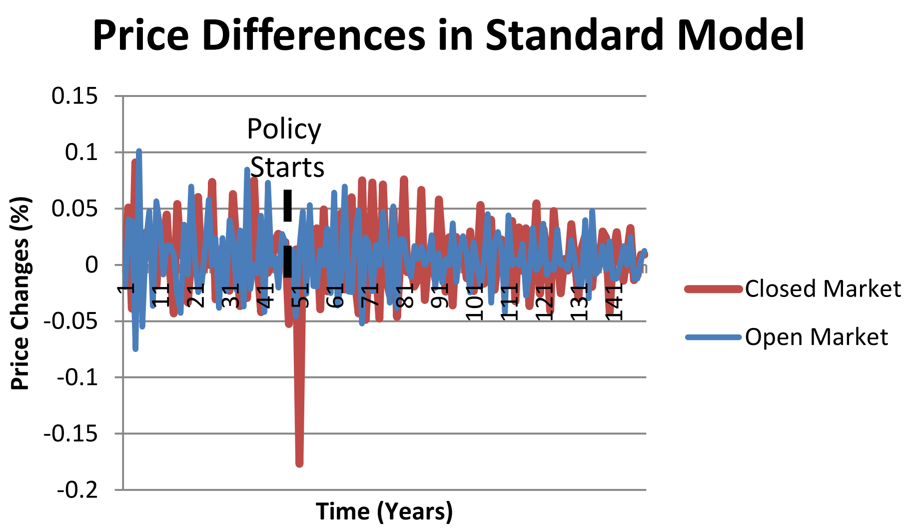


Region	Effect on Price Changes	Explanation
A	Dampens increase	Foreign growth stronger than domestic, policy removes large positive factor for growth of prices.
B	Exaggerates increase	Foreign growth weaker, policy removes small positive factor.
C	Exaggerates increase	Policy removes small negative growth factor.
D	Changes from decrease to increase	Policy removes large negative, keeps small positive factor.
E	Dampens decrease	Policy removes large negative, keeps small negative factor.
F	Exaggerates decrease	Policy removes small negative, keeps large negative factor.
G	Dampens decrease	Policy removes small positive, keeps large negative factor.
H	Changes from increase to decrease	Policy removes large positive, keeps small negative factor.

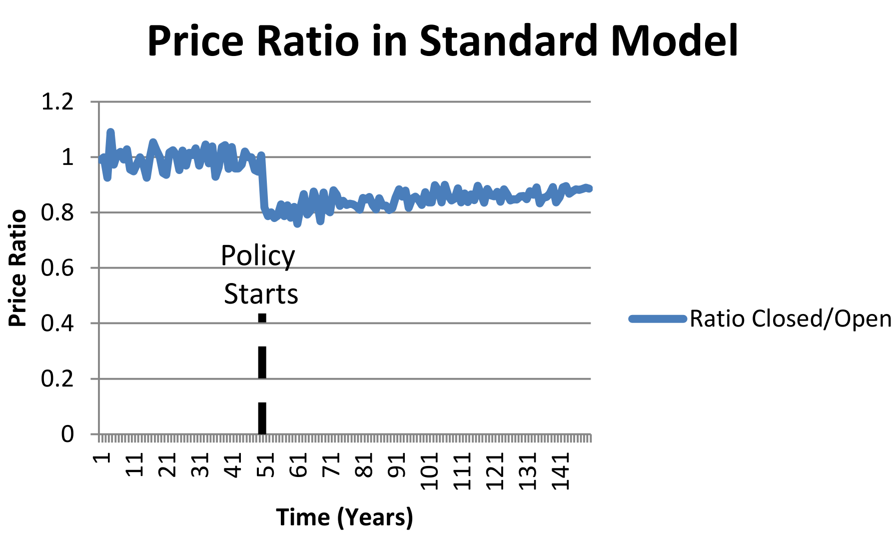
Figure 5: Simulation from Standard PV Model



Shows one-time affect on price levels.

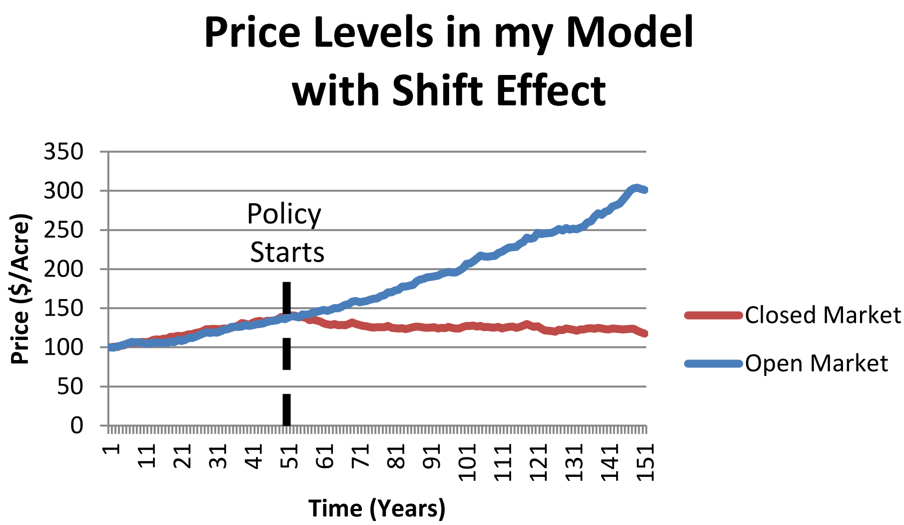


Shows one-time affect on price changes.

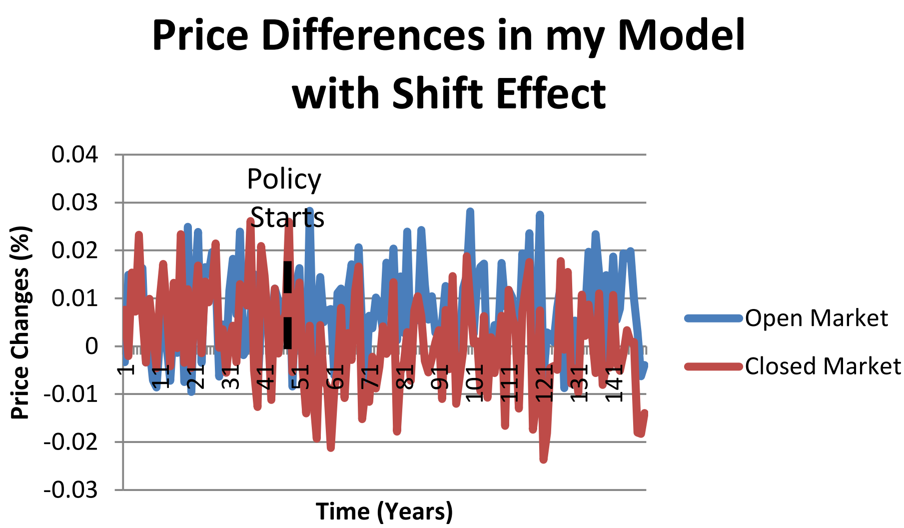


Shows one-time affect on price ratio that disappears over time.

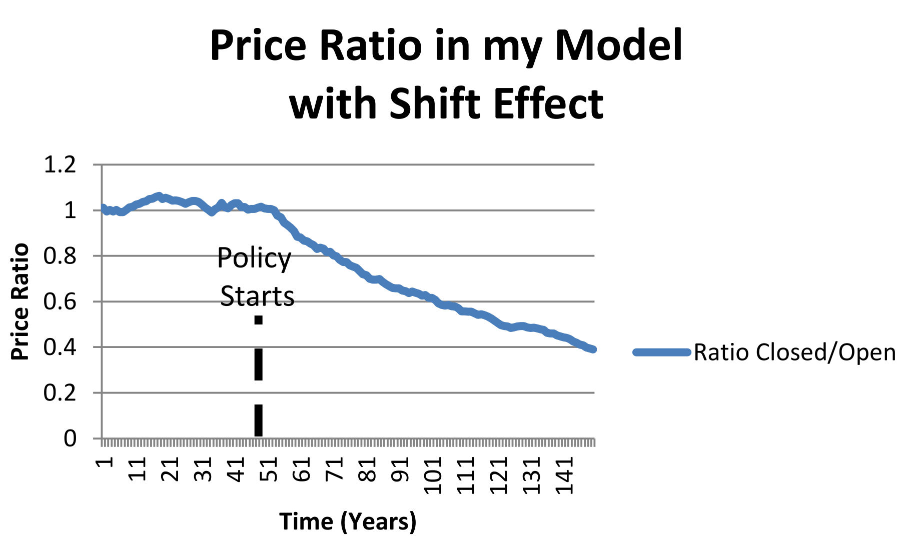
Figure 6: Simulation from my Model when Policy causes a Shift



Shows persistent effect on price levels.

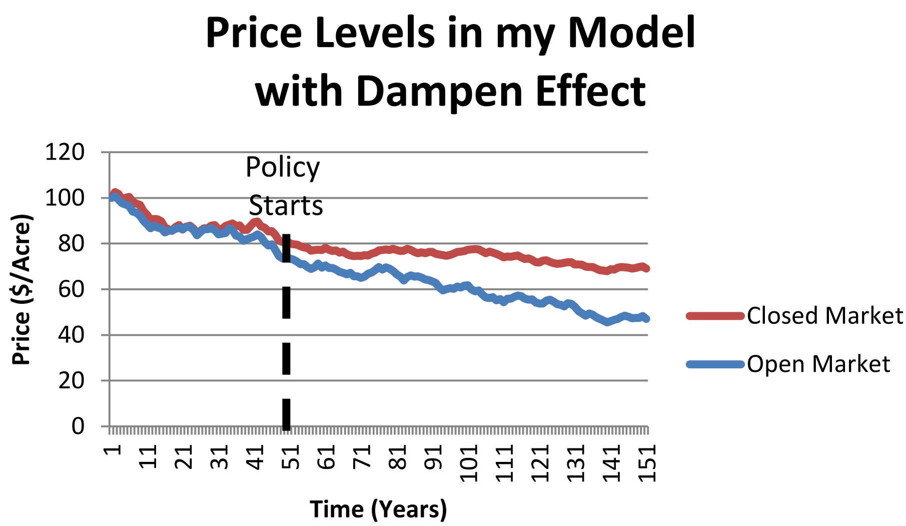


Shows structural break in price changes.

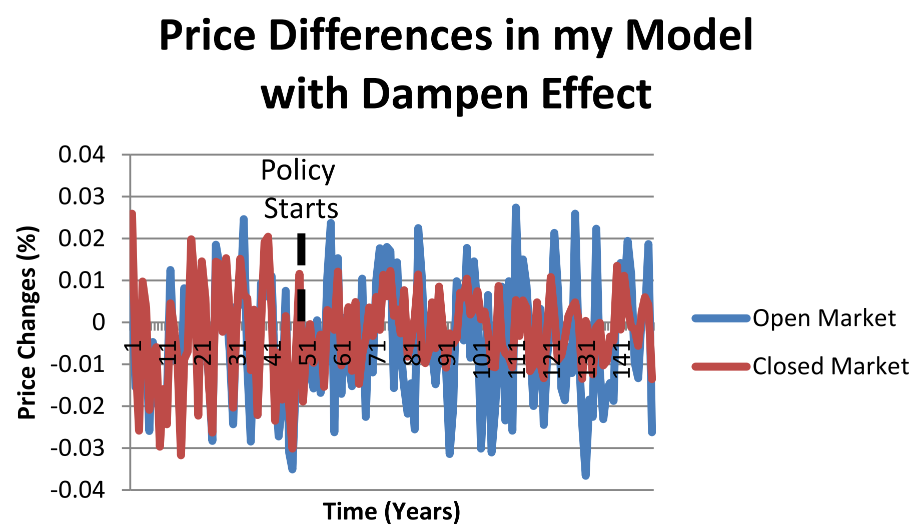


Shows a persistent effect on the ratio of prices.

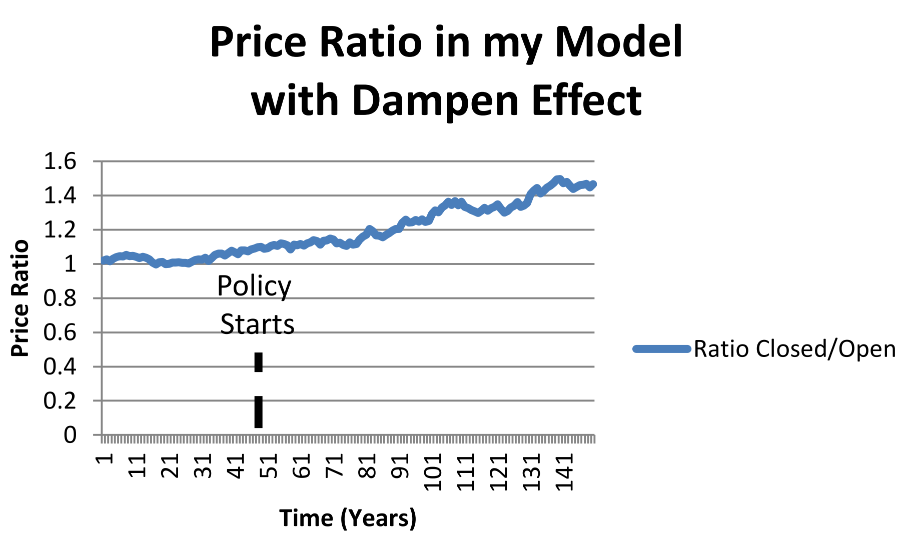
Figure 7: Simulation from my Model when Policy causes Dampening



Shows persistent effect on price levels, where policy causes over-pricing.



Shows structural break in price changes.



Shows a persistent effect on the ratio of prices, where the ratio increases over time.