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USING COINTEGRATED VAR MODELING TO COMPARATIVELY AND EMPIRICALLY ASSESS EFFECTS OF ALTERNATIVELY-FOCUSED POLICIES ON U.S. SOFT WHEAT MARKETS

Ronald A. Babula*

ABSTRACT

After establishing the importance to policy formation and analysis of U.S. wheat product markets, the paper extends prior research on quarterly U.S. all-wheat product markets by applying, for the first time, cointegrated VAR modeling to a monthly system of U.S. soft wheat markets that includes a soft wheat futures market linkage. The study then uses the estimated upstream/downstream U.S. soft wheat market product model to comparatively and empirically assess the effectiveness of two sets of policies/events in influencing and managing the markets through price: selected commodity-focused farm/trade policies/events vs. those focused on financial and futures markets. First time empirical econometric assessments are generated that demonstrate that the policies/events with a commodity focus are more than doubly effective than financial/futures policies/events in influencing and managing the modeled soft wheat-based markets, and any patterns of wheat-based food price inflation that should arise. Results provide the first empirical estimates of how financial/futures market events/policies have real, statistically strong effects on the modeled soft wheat-based markets. Policy insights for the modeled soft wheat markets are also provided concerning trade agreements and trade remedies such as TRQs and dumping/countervailing duty orders.

JEL codes:C32, L66, Q18

Keywords:cointegration, cointegrated vector autoregression, comparative policy analysis, U.S. wheat-related product prices.

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JUSTIFICATION, PURPOSE AND REVIEW OF RELATED LITERATURE

U.S. markets for wheat and wheat-related products have long comprised a fertile, although contentious, area of farm/trade policy formation, trade remedy implementation, trade investigations, and trade disputes. The contentiousness of this area has been particularly strong between the U.S. and Canada – particularly since the early 1990s – as evidenced by the following events, studies, and policies by the U.S. International Trade Commission (USITC),the U.S. Departments of Agriculture and Commerce, and other U.S. (and Canadian) agencies:

- The high-profile 1994 USITC Section-22 investigation of material injury on the U.S. wheat farm support program from wheat, wheat flour, and semolina imports (primarily from Canada) [see USITC 1994].
- A 1995 bi-national inquiry onus./Canadian trade in grains (primarily wheat) [see Canada-U.S. Joint Grains Commission 1995].
- U.S. imposition of two tariff rate quotas (TRQs) on imports of certain Canadian wheat for the year ending September 11, 2011, 1995 (Glickman and Kantor).
- A USITC (2001) Section-332 fact-finding investigation on Canadian wheat trading practices.
- U.S. anti-dumping/countervailing duty (AD/CVD) orders placed on certain imports of Canadian wheat during 2002-2005 (USITC 2003).
- Various U.S. farm bills of 1996, 2002, and 2008.

U.S. markets for wheat-based products clearly comprise one of the most productive areas for generating results from, and extending the methods of, policy analysis.

Given the policy importance and potential for relevant policy analysis comprised by U.S. wheat-based markets, along with other newer policy-relevant developments discussed below, this paper has three inter-related goals or motivations. First is to extend recent econometric research that illuminated policy-relevant dynamic workings and inter-relationships among U.S. markets using “all-wheat” (wheat quantities aggregated across the five U.S. wheat classes) from the farmgate upstream to downstream food markets that use wheat: Babula, Rogowsky, and Romain (BRR) and Babula, Bessler, and Payne (BBP).This paper extends the BRR/BBP work in a logical policy direction: it econometrically models U.S. upstream/downstream markets for U.S. soft wheat products, an important wheat food subset of all-wheat products. In so doing, this paper extends and deepens overall knowledge and understanding of the workings and inter-connections of U.S. wheat product markets generally.

Second, this study provides the literature’s first known use of cointegrated VAR methods to incorporate a wheat futures market linkage into a dynamic model of U.S. upstream/downstream wheat-related markets, and to illuminate the role that wheat futures market events and policies play in the working and inter-relations among such U.S. wheat-related markets. Such interest in the role of futures markets for wheat (and commodities generally) is dramatically increasing with the expanding debate over the consequences of increasing speculative trading of wheat futures on commodity markets and related prices. Auerlichet. al. (pp. 6-11) noted that during 2004-2009,open interest in the in the Chicago

Board of Trade (CBOT) soft red wheat (SRW) futures contract surged dramatically by about 200%.They further noted that this dramatic increase arose from an expansion of the traditional pool of wheat futures traders, who have primarily focused on risk management and price discovery, to include substantial numbers of non-traditional, speculative, and profit-seeing agents from large index and hedge funds who hold wheat contract positions as an asset class. The debate over the effects of such increasing volumes of speculative trading on U.S. wheat futures and wheat-related product markets has been particularly escalating in the wake of the recent July, 2010 enactment of the massive Dodd-Frank financial reform bill, and there has been no empirical estimation of such effects located. This paper's findings on the role that wheat futures price plays on U.S. upstream farm and downstream wheat-using food product markets, and in turn on related food inflation issues, is of keen interest to researchers, policy analysts, and agribusiness agents.

The third is to extend important work by Hua and by Lambert and Miljkovic that established cointegrated vector autoregression (cointegrated VAR) modeling as a useful policy-analytic tool for commodity and food markets. More specifically, these two studies demonstrated cointegrated VAR modeling's use in illuminating dynamic policy transmission mechanisms from non-commodity markets to food- or commodity-related markets, and then used such mechanisms to comparatively and empirically assess the effectiveness of alternative policies in influencing commodity price movements and in managing food/commodity inflation patterns. This paper extends this prior work by using cointegrated VAR modeling to estimate the policy transmission mechanism for a U.S. system of upstream/downstream soft wheat-related markets(that includes a wheat futures market linkage).The model is then used to comparatively and empirically assess the effectiveness of selected policies in influencing such markets and in managing wheat-related trends in commodity and food cost inflation. Results include a number of empirical estimates of wheat market-propelling parameters that, in turn, permit a comparative assessment of two policy groups in managing and addressing U.S. food cost/inflation issues: selected farm and trade policies/events that focus on the U.S. soft wheat commodity market and financial regulatory and futures market policies/events such as the rising volume of non-traditional wheat futures trading and changes in futures market specifications.

Babula, Bessler, and Payne (BBP 2004) noted that the value-added side of the food industry, unlike farm commodity markets, has been neglected as an empirically researchable area because of a lack of published data, insofar as food industry agents often consider production, distribution, and other related data as business confidential information beyond the public domain. To mitigate this research gap for U.S. wheat-related markets, BBP combined Bernanke's (1986) structural VAR modeling methods with directed acyclic graph (DAG) analysis of evidentially-based lines of food product market causality and estimated a "Bernanke/DAG" VAR model of the following six U.S. all-wheat-based markets using quarterly 1986-2003 data: the farm wheat market upstream, and downstream wheat-based markets for flour, mixes/doughs, bread, wheat-based breakfast cereals, and cookies/crackers. BP's statistical estimates of coefficients and market parameters and analyses of impulse response function simulations and forecast error variance decompositions provided an array of results that empirically illuminated how policies that influence the upstream farm market for wheat dynamically influence downstream U.S. wheat-based food prices. Results also included policy-relevant empirical estimates of crucial market-propelling elasticities of demand and price response that in turn implied empirically measurable effects of selected farm and trade policies for the benefit of farm/food policy makers, researchers, and agribusiness agents.

Hua demonstrated the use of cointegrated VAR methods in establishing the existence and empirical nature of policy transmission mechanisms from macroeconomic (macro) sector policies to global commodity markets through price. He applied cointegrated VAR modeling methods to nonstationary, quarterly, and inflation-adjusted (deflated) data during 1970-1993, and focused on five global non-oil commodity prices and three macro policy variables. The five global commodity prices included those for an aggregated basket of "primary commodities," metals/minerals, agricultural raw materials, food products, and tropical beverages, while the macro policy variables included a world industrial production index, an exchange rate index of the U.S. dollar relative to other world currencies, and a proxy for global interest rates. Hua conducted Johansen's (1988) cointegration test five times to test whether each of the global commodity prices indices was cointegrated with the three macro policy variables,[1] and in each case, uncovered one cointegrated vector or CV among the commodity price and the macro variables. He estimated five error correction equations where the first differences of each commodity price was posited as a function of the lagged values of itself and of the three differenced macro levers, along with the relevant error correction term. His tests and dynamic estimations generated three insights on how global macroeconomic policies dynamically transmit effects to global non-oil commodity markets though price linkages. First, statistical evidence strongly suggested the existence of macro/commodity policy transmission mechanisms. Second, policies promoting global economic growth likely stimulate world commodity demand and in turn commodity prices. And third, policies that appreciate relative U.S. dollar values and/or reduce global interest rates increase global commodity demand and prices.

Lambert and Miljkovic (2010) applied cointegrated VAR methods to identify policies that most effectively address U.S. food price inflation issues. They addressed the debate of whether the 2006-2008 U.S. food inflationary surge was induced by farm price and manufacturing wage increases or by surges in energy costs and consumer incomes. Having modeled U.S. food prices, farm prices, fuel prices, wages, and consumer income, as a cointegrated VAR model with non-stationary monthly 1970-2009 data, two cointegration relationships emerged from the model's long run error correction component that Lambert and Miljkovic then analyzed and interpreted. Results suggested that farm prices and manufacturing wages, rather than energy costs and consumer income levels, are effective determinants of U.S. price inflation. In addition to establishing the cointegrated VAR methods as a major policy-analytic tool to address food inflation issues, they concluded that policies focusing on farm product markets and manufacturing wages most effectively address food inflation issues.

Babula, Rogowsky, and Romain (BRR) extended and updated BBP's earlier VAR modeling analysis of the same six U.S. wheat-based markets for a quarterly 1985-2005 sample. Taking established and recent advances in Johansen and Juselius' cointegrated VAR methods outlined in Juselius, Juselius and Franchi, and Juselius and Toro, and having placed more appropriate focus than the earlier BBP analysis on the data's nonstationarity properties, BBR modeled the variables as a cointegrated VAR. In so doing, BRR analytically

[1]Hua also included a global deflated index of crude petroleum price for various reasons. These reasons and the analytical results related to the global crude petroleum price are not directly related to this paper's analysis, and these petro-based results are not herein included.

dichotomized BBP's earlier reduced form levels VAR model into shortrun and long run (or error correction) components, the latter of which provided useful cointegration properties that were exploited and interpreted to render more precise, structural, and theoretically based results than BBP for U.S. wheat-based markets. Three cointegrating relationships emerged that included a U.S. all-wheat supply as well as two U.S. upstream/downstream wheat-related price transmission mechanisms. These relationships were in turn developed through application of economic/econometric theory, formal hypothesis testing, and statistical inference to provide an array of policy implications, estimates of market-propelling parameters, and empirical measurement of the effects of a specific set of farm and trade policies that are relevant to the six U.S. wheat-related markets.

The remainder of this paper unfolds in six sections. The first provides an overview of cointegrated VAR modeling methods, a list of modeled markets, and the modeled time series and data sources. The second summarizes efforts to first achieve an adequately specified levels VAR model and its unrestricted vector error correction (VEC) equivalent which are ultimately used to exploit what are later revealed to be the modeled system's substantial cointegration properties. A rigorous analysis of the model's statistical adequacy based on the results from a battery of diagnostic mis-specification tests suggested by Juselius (2006), Juselius and Toro, and Juselius and Franchi is provided. In a third section, evidence from Johansen and Juselius' well-known trace tests and other supplemental sources is used to determine the number of cointegrating vectors (CVs). The cointegration space is restricted for reduced rank. A fourth section employs established hypothesis test procedures, based on economic and econometric theory and market expertise, on the rank-restricted cointegration space to illuminate long run economic relationships that drive and inter-connect U.S. upstream/downstream markets related to soft wheat. A fifth section interprets the finally restricted CVs and their estimated cointegration parameters for economic content and to comparatively assess the effects of selected farm, trade, and financial regulatory policies on the modeled U.S. wheat product markets. Included is a comparative assessment of the focused policies' relative effectiveness in managing wheat-related U.S. food inflation issues. A summary of conclusions and policy insights concludes the paper.

TIME SERIES ECONOMETRICS, MODELED MARKETS AND DATA SOURCES

It is well known that economic time series often fail to meet conditions of weak stationarity (aka, stationarity and ergodicity) required of valid inference, and in some cases unbiased estimates, from regressions using time-ordered data (Granger and Newbold, pp. 1-5).And while data series are often individually non-stationary, they can form vectors with stationary linear combinations, such that the inter-related series are "cointegrated" and move in tandem as an error-correcting system (Johansen and Juselius).

A search of monthly U.S. soft wheat-related market data was conducted, with a focus on obtaining monthly prices of wheat, a related futures price, and the important related U.S. wheat-based food prices. As a result, I propose modeling five monthly U.S. endogenous price variables for soft wheat products (denoted throughout by the parenthetical labels) sourced as follows:

- Chicago Board of Trade's monthly price for the soft red winter (SWR) wheat futures contract (PFUTURES).[2]
- U.S. wholesale price of soft red winter wheat (PSOFTRED).This is the U.S. producer price index (PPI), soft red winter wheat, series no. WPU01210104 from the U.S. Department of Labor, Bureau of Labor Statistics (Labor, BLS 2010).
- U.S. wholesale price of wheat flour (PFLOUR).This is the PPI for wheat flour made in flour mills (flour mixes excluded), series no. PCU3112113112111 from Labor, BLS (2010).
- U.S. wholesale price of crackers and related products (PCRACKERS).This is the PPI for crackers, biscuits, and related products, series no. PCU 3118213118212 from Labor, BLS (2010)
- U.S. wholesale price of various cake mixes (PCAKEMIX).This is the PPI for cake mixes made from purchased flour, series no. PCU31182231182201 from Labor, BLS (2010).

All monthly data were seasonally unadjusted and collected for the January, 1993 – June, 2010 period (1993:01-2010:06), a sample period for which observations were available for all five variables. As shown below, all five modeled series are non-stationary or integrated of order-one [I(1)].The U.S. Department of Agriculture does not publish monthly quantity and usage tables for wheat. The unavailability of monthly data on U.S. consumption, supply, shipments, and/or stocks of soft wheat and related processed food products precluded the inclusion of quantity variables. While inclusion of both price and quantity variables would have been preferable, the literature has demonstrated how a cointegrated VAR, beset with a lack of quantity data for the modeled markets, may rely on reduced form qualities and on the theory of the stochastic process to capture a market's forces of demand/supply through inclusion of a single price equation (Hamilton, p. 71; Hua; Lambert and Miljkovic).Diagnostics presented below nonetheless demonstrate that the modeled wheat price equations achieved adequate literature-established standards of specification adequacy.

Following Juselius and Toro and Juselius (chs. 1-4), I examined the modeled data's logged levels and differences to assess the data's stationarity properties. Such examinations led to formulation of specification implications of these properties that utilize inherent stores of information to avoid compromised inference and spurious regressions (see Granger and Newbold, pp. 1-5).Using such statistically-supported specification implications results below in a statistically adequate VAR model with which the modeled system's cointegration properties may be exploited.

Statistical Model: Levels VAR and Unrestricted VEC Equivalent[3]

Sims (1980) and Bessler (1984) note that a VAR model posits each endogenous variable as a function of k lags of itself and of each of the system's remaining endogenous variables.

[2]No. 1 northern spring wheat no. 2 soft red, no. 2 hard red winter, and no. 2 dark northern spring at par.
[3] This section draws heavily on the seminal article by Johansen and Juselius and the book by Juselius.

The above wheat-related variables render the following five-equation VAR model in logged levels:

$$X(t)=a(1,2)*PFUTURES(t-1)+ \ldots + a(1,k)*PFUTURES(t-k) + a(2,1)*PSOFTRED(t-1)+ \ldots + a(2,k)*PSOFTRED(t-k) + a(3,1)*PFLOUR(t-1)+ \ldots +a(3,k)*PFLOUR(t-k)+ a(4,1)*PCRACKERS(t-1)+ \ldots +a(4,k)*PCRACKERS(t-k) + a(5,1)*PCAKEMIX(t-1)+ \ldots +a(5,k)*PCAKEMIX(t-k)+ a(c)*CONSTANT+ a(s)*SEASONALS+ \gamma(t) \quad (1)$$

In (1), X(t) = PFUTURES(t), PSOFTRED(t), PFLOUR(t), PCRACKERS(t), and PCAKEMIX(t).

The asterisk denotes the multiplication multiplier; the t refers to current time period-t; and $\gamma(t)$ is a vector of white noise residuals. The a-coefficients are ordinary least squares regression estimates with the first parenthetical digit denoting the five endogenous variables as ordered in X(t)'s definition, and the second reflecting the lagged value. The k=6 lag structure was proscribed by results from the application of Tiao and Box's (1978) lag search procedure. The a(c) denotes the intercept on a constant of 1.0.Equation 1 also includes a vector of 11 centered seasonal variables and a number of other binary variables discussed below.

It is well known that a levels VAR of a lag order-k can be equivalently written more compactly as an unrestricted vector error correction (unrestricted VEC) model (Juselius 2006, pp. 59-63; Johansen and Juselius):

$$\Delta x(t) = \Gamma(1)*\Delta x(t-1) + \ldots + \Gamma(k-1)*\Delta x(t-k+1) + \Pi*x(t-1) + \Phi D(t) + \varepsilon(t) \quad (2)$$

The endogenous variable number, p, is five. The $\varepsilon(t)$ are white noise residuals; the delta is the difference operator, while the x(t) and x(t-1) are p by 1 vectors of the endogenous variables in current and lagged levels. The $\Gamma(1), \ldots, \Gamma(k-1)$ terms are p by p matrices of short run regression coefficients, and Π us a p by p long run error correction term to account for endogenous levels. The $\Phi D(t)$ is a set of deterministic variables, including an array of binary (dummy) variables that will be added to address stationarity and specification issues as the analysis unfolds below. The error correction term is decomposed as follows:

$$\Pi = \alpha*\beta', \quad (3)$$

Theα is a p by r matrix of adjustment coefficients (r is the number of cointegrating relationships or the rank of Π discussed below).The β is a p by r vector of cointegrating parameters.

The error correction term retains the levels-based and other long run information: linear combinations of non-differenced and individually I(1) endogenous levels variables (under cointegration); permanent shift binaries to capture more enduring effects of policy/market events (presented below); and a linear trend. The term $[\Gamma(1)*\Delta x(t-1) \ldots \Gamma(k-1)\Delta x(t-k+1),\Phi D(t)]$ collectively comprises the model's short run/deterministic component that includes the permanent shift binaries in differenced form, observation-specific outlier binaries (introduced below), and seasonal binaries.

The VAR model or its unrestricted VEC equivalent is a reduced form one, where estimated relations reflect a mix of demand- and supply-side elements, often without clear structural interpretations (Hamilton, ch. 11).Johansen and Juselius dichotomized Sims' VAR model into the above-cited long and short run components in equation 2 that extended the original levels VAR methods. With cointegrated variables, one can identify structural error correction relationships in Π from what was once exclusively the reduced form levels VAR relationships by separating-out the long run error correction term; by applying economic theory and statistical inference using Johansen-Juselius hypothesis test tools; and through reduced-rank estimation with statistically supported restrictions from such hypothesis tests (Johansen and Juselius).Following related research (BRR, pp. 247-248), the following six permanent shift binary variables (binaries) were considered to capture effects of important policies/events:(i) NAFTA for the 1994 implementation of the North American Free Trade Agreement (NAFTA); (ii) URUGUAY for the Uruguay Round's (UR's) 1995 implementation; (iii) FBILL96, FBILL02, and FBILL08 for the implementation of the 1996, 2002, and 2008 U.S. farm bills; and HIDD0708 for the 2007-2008 spike in U.S. and global commodity demand and prices.

Following Juselius' (chs. 1-4) procedure, one ultimately obtains a statistically adequate unrestricted VEC through a series of sequential estimations using Estima's and Dennis' software. Following prior related work, I first added a trend, 11 centered seasonal, and the six permanent shift binaries to equation 2 for the first estimation, and a series of diagnostic test results suggested that inclusion of these deterministic variables was warranted.

Thereafter, I added an array of month-specific short run outlier binaries – generally one variable per estimation – to the model's short run component. Each outlier binary was retained if the following battery of diagnostics (explained in table 1) took on patterns indicative of improved specification: trace correlation; Doornik-Hansen tests of residual normality; tests for serial correlation and heteroscedasticity; and indicators of skewness and kurtosis. Such outliers were chosen based on Juselius' (2006, ch. 6) method of identifying and including outliers based on Bonferoni's criterion.[4]An appropriate binary in differenced form was specified for inclusion in the model's short run/deterministic component, and the binary was retained if the latter-cited battery of diagnostics suggested that its inclusion enhanced specification adequacy. Seventeen outlier binary variables were ultimately included.[5]

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[4] More specifically, when an observation's absolute standardized residual value equaled or exceeded 3.0, the observation was deemed representable through a potentially includable outlier binary. Juselius' (ch. 6) method of outlier binary identification based on Bonferoni's criterion as modeled through Estima's INVNORMAL procedure was followed. Given this study's 210 observations, the procedure proscribed a Bonferoni criterion of the observation's absolute standardized residual value equaling or exceeding 3.7. Having noticed repeated instances where observations had potentially extraordinary effects with absolute standardized residual values at 3.0 or more, I followed recent related research and crafted a more conservative Bonferoni absolute value of 3.0 or more (see Babula, Rogowsky, and Romain , pp. 248-249).

[5]To conserve space, I do not include extensive variable-by-variable analyses and estimation results. All included binary variables were of the transitory blip form following specification procedures outlined in Juselius (2006, ch. 6). These binary variables are formulated in differenced form to conform with inclusion within the unrestricted VEC model's short run/deterministic component. The differenced binaries' definition is reflected by the label: "dt" denotes a transitory binary with short run effects, and the digits refer to the dates of unity values for a binary in first differences. For example, dt1996_0506 refers to a May, 1996 influence leading to non-zero values for May and June, 1996 when placed into first differences. The binary variables dt1993_1011, dt1994_0506, and dt199512_199601 were included to capture the expectionary and residual influences not fully accounted for by the NAFTA and URUGUAY permanent shift binaries defined to account for the influences of the back-to-back implementations in 1994 and 1995 of the NAFTA and Uruguay Round free trade agreements, respectively. The following five transitory binaries were included to capture

A statistically adequate VAR model (and its unrestricted VEC algebraic equivalent) emerged from the array of sequential estimations. Table 1 provides a battery of diagnostic test values for two estimations of the unrestricted VEC model: the initially estimated model before sequential estimations aimed at specification improvement and with no deterministic variables except for an intercept, and the model judged as statistically adequate after specification efforts led to the inclusion of the six permanent shift binaries, a time trend, seasonal variables, and an array of outlier binaries.

Table 1 suggests clear benefits to the specification efforts, reflected by the 137% rise in the trace correlation, a goodness-of-fit measure. Further, Table 1's evidence suggests that serial correlation (LM test results) and heteroscedasticity (ARCH test results) were not issues.

Doornik-Hanson (D-H) values test the null hypothesis (null) that estimated equation residuals behave normally, with rejection occurring for D-H values above critical values (or for p-values below 0.05). With an ultimate p-value of 0.33, system D-H test evidence fails to reject the null that the system of estimated values ultimately behave normally. The univariate D-H values ultimately fell below the critical value of 9.2 (5-percent level) for all five equations. Benefits of specification efforts are particularly evident from the noticeable declines in univariate D-H values for the PCRACKERS and PCAKEMIX equations.

Table 1 also suggests that indicators of skewness and kurtosis were all within literature-established acceptable ranges. As a result, the unrestricted VEC model after specification efforts was judged as statistically adequate by literature-established standards, and appropriately serves as the model of which the cointegration properties may be exploited.

COINTEGRATION: TESTING FOR AND IMPOSING APPROPRIATE REDUCED RANK

The endogenous variables are shown below to be I(1), and their differences are I(0). Cointegrated variables are driven by common trends and stationary linear combinations called cointegrating vectors or CVs (Juselius, p. 80). The Π-matrix is a p by p matrix equal to the product of two p by r matrices: β containing error correction estimates that combined intor < p number of CVs under cointegration of the five individually nonstationary wheat-based prices, and α containing the adjustment-speed coefficients.

exectationary and/or residual influences not captured by the previously defined permanent shift binary, FB1996, designed to capture the implementation of the 1996 U.S. farm bill: dt1996_0304, dt1996_0506, dt1996_0809, dt1997_0405, and dt1997_1011. The following two transitory binaries were included following prior research by Babula, Rogowsky, and Romain (p. 248) to capture the beginning and end of the 2002-2005 period during which the U.S. International Trade Commission conducted a dumping case on certain U.S. imports of Canadian-sourced wheat: dt2002_1112 and dt2005_0607. The following two transitory binary variables were included to capture the extraordinary influences of approximately the beginning and end of a global run –up in bakery production costs noted in Babula, Rogowsky, and Romain (p. 248) : dt2000_0203 and dt2000_0809. The following three transitory binaries were included to account for the influences not fully captured by two previously defined permanent shift binaries of HIDD0708 to account for the recent surge and receding in global grains prices and FB2008 to account for the implementation of the 2008 U.S. farm bill: dt200706_200710, dt200811_201003, and dt2008_0205. Two transitory binaries were defined to account for likely effects of the accelerating U.S. economic recovery and the receding of global commodity prices: dt2009_0708 and dt2010_0405.

Table 1. Mis-specification Tests for the Unrestricted VEC: Before and After Specification Efforts

Test and/or equation	Null hypothesis and/or test explanation	Prior efforts at specification adequacy	After efforts at specification adequacy
Trace correlation	system-wide goodness of fit: large proportion desirable	0.245	0.58
ARCH tests for heteroscedasticity (lags 1, 4)	Ho: no heteroscedasticity by 1st for system. Reject with p-values less 0.05	290.24 (p=0.002)	249.95 (p=0.63)
LM test, serial correlation	Ho: no heteroscedasticity at lag-1.Reject for p<0.05	26.89 (p=0.36)	27.47 (p=0.33)
Doornik-Hansen test, system-wide normality	Ho: modeled system behaves normally. Reject for p-values below 0.05.	241.9 (p=0.000000, see note)	16.42 (p=.09)
Doornik-Hansen test for normal residuals (univariate)	Ho: equation residuals are normal. Reject for values above 9.2 critical value.		
ΔPFUTURES		4.39	1.38
ΔPSOFTRED		2.05	0.99
ΔPFLOUR		9.29	0.86
ΔPCRACKERS		53.23	1.35
ΔPCAKEMIX		171.44	5.93
Skegness (kurtosis) univariate values	Skewness: ideal is zero; "small" absolute value acceptable kurtosis: ideal is 3.0; acceptable range is 3.0-5.0.		
ΔPFUTURES		0.334 (3.42)	0.185 (3.09)
ΔPSOFTRED		0.217 (3.20)	0.092 (3.17)
ΔPFLOUR		0.354 (4.56)	-0.07 (3.16)
ΔPCRACKERS		0.822 (7.58)	0.119 (3.21)
ΔPCAKEMIX		-0.036 (10.78)	0.247 (3.71)

Note.—The p-value "p=0.000000" implies that the value was adequately small so as not to register at the 6th decimal place.

Not yet universally used by U.S. agricultural and policy econometricians, there have been recent refinements of the cointegrated VAR model to extend the purview of considered evidence in determining reduced rank beyond a traditional sole reliance on Johansen and Juselius trace test results (see Juselius; Juselius and Toro, p. 139; and Juselius and Franchi). As a result of Juselius' strong recommendation against sole reliance on trace tests, I base determination of the cointegration space's reduced rank not only on trace test results, but on two other sources of supplementary evidence: examination of the patterns of characteristic unit roots in the companion matrices under appropriate assumptions of reduced rank as well as on an analysis of the patterns of statistical significance of α-estimates in relevant CVs.

Table 2 provides nested trace test evidence for rank determination. Evidence at the 5-percent level is sufficient to reject the first three null hypotheses (nulls) that r ≤ 2, and fails to reject that r ≤ 3.In this nested test context, these trace tests suggest that r = 3, and that there are three CVs that error-correct this set of individually nonstationary prices into a stationary system. However, the hypothesis test failing to reject that r is three is a marginal result, suggesting that examination of further evidence is appropriate.

Table 2. Nested Trace Test Statistics and Related Information

Null Hypothesis	Trace Value	95% Fractile	Result
Rank orr ≤ 0	140.48	99.3	Reject null that r ≤ 0.
Rank orr ≤ 1	96.43	74.46	Reject null that r ≤ 1.
Rank orr ≤ 2	61.48	53.57	Reject null that r ≤ 2.
Rank orr ≤ 3	32.97	36.53	Reject null that r ≤ 3.
Rank orr ≤ 4	11.08	23.25	Reject null that r ≤ 4.

Note.—As recommended by Juselius, CATS2–generated fractiles are increased by 6*1.8 or 10.8 to account for the six permanent shift binary variables restricted to lie within the cointegration space.

If the chosen r is appropriate, then there should be p-r characteristic unit roots with the (p-r+1) st root being sub-unity. Under r=3, there are (p-r) or 2 unit roots with the third equaling 0.94, a value close to unity. This result suggests that r should perhaps be reduced to 2 such that (r-p) is raised to 4, and thereby suggests that r may be 2 rather than 3. Under r=2, there are (p-r) or 3 unity roots, with the fourth equaling 0.84, a value more substantially below unity than the (p-r+1) st root under r=3.[6] These patterns of characteristic roots suggest that the reduced rank is more likely 2 than 3.

A CV that actively participates in, and that should be considered part of, the model's error correction mechanism should display high statistical significance levels of its adjustment coefficients (Juselius, pp. 139-144). The estimated unrestricted VEC model's first three CVs generated the following numbers of α-estimates (of the five) that were significant: four in CV1, three in CV2, and one in CV3.[7]

Since the majority of prices in CV1 and CV2 generated significant adjustment coefficients, CV1 and CV2 actively participate in the error correction process and should be included within the error correction space. That only one of CV3's five α-estimates achieved statistical significance suggests CV3's lower level of error correction mechanism participation, and suggests that CV3 may not belong within the cointegration space.

The marginal trace test results suggesting that r is three rather than two are strongly offset by analyses of characteristic roots in relevant companion matrices and patterns of α-estimate significance that suggest that r is two rather than three. It is concluded that the error correction space's reduced rank (r) is more likely two than three, and that there are two, rather

[6]To conserve space, the characteristic roots under these two r-assumptions, as well as other r-assumptions, were not reported and are available from the author on request.

[7] The absolute critical value for an α-estimate's pseudo t-value is 2.6 at the 5-percent significance level (Juselius, p. 142). Thus, for example, four of CV1's five α-estimates generated absolute t-values that exceeded 2.6. To conserve space, the five vectors or α-estimates for the unrestricted VEC's five endogenous prices are not reported and are available on request.

than three, cointegrating relationships that tie-together the five individually nonstationary prices into a stationary system.

HYPOTHESIS TESTS ON THE TWO UNRESTRICTED CVS

One begins with the two unrestricted cointegrating relationships (not reported due to space considerations) that emerged from imposing the reduced rank of r=2, as discussed above. One conducts a sequential series of hypothesis tests on the cointegration space, and then re-estimates the system with the statistically-supported restrictions imposed. Hypothesis tests on the beta coefficients take the form:

$$\beta = H^*\varphi \quad (4)$$

Above, β is a p1 by r vector of coefficients on variables included in the cointegration space,[8] and H is a p1 by s design matrix, with s being the number of unrestricted or free beta coefficients. The φ is an s by r matrix of unrestricted beta coefficients. The hypothesis test value or statistic is:

$$2\ln(Q) = T^*\sum [(1-\lambda_i^*) / (1-\lambda_i)] \text{ for } i = 1,2 \ (=r) \quad (5)$$

Asterisked (non-asterisked) eigenvalues (λ_i= 1,2) are generated with (without) the tested restrictions imposed.

Following Juselius' (ch. 10) recommendations and related BRR work in this journal, the first set of tests on the betas are systems-based and rank-dependent stationarity tests, as opposed to more traditionally used univariate tests such as Dickey-Fuller and Phillips-Perron tests. Juselius, Juselius and Toro, and Juselius and Franchi contend that using critical values from more traditional one-dimensional unit root tests are not appropriate for models such as this one with five endogenous variables. They instead recommend a systems based and rank-dependent likelihood ratio test of each endogenous variable's stationarity that is dependent on the imposed rank of r (here 2), as prpgrammed in Dennis. Five such tests were conducted and evidence was sufficient to reject the hypotheses that each of the five variables was stationary in logged levels, suggesting that all five endogenous variables are non-stationary or I(1) in logged levels.[9]

Juselius (chs. 10-12) suggests that one consider economic and statistical theory with the empirical nature of the yet un-identified co integrating parameter estimates that emerged from the Johansen-Juselius reduced rank estimation after having imposed the rank of r=2.She

[8] The p1 equals p=5 endogenous variables plus the seven deterministic variables restricted to the cointegration space, that is p1=12.

[9] More specifically, equation 3 is rewritten as β^c=[b,φ]. Let p1 be the new dimension of 12 reflecting 5 endogenous variables and 7 deterministic components in the cointegration space. For the latter equation, β^c is a p1 by r or 12 by 2 beta matrix with one of the variable's levels restricted to a unit vector; b is a p1 by 1 or 12 by 1 vector with a unity value corresponding to the relevant variable whose stationarity is being tested; and φ is a p1 by (r-1) or 12 by 1 matrix of the remaining unrestricted CVs. Given the rank of 2, then the test values and parenthetical for the five stationarity tests are as follows, with the null of stationarity rejected for "small" p-values below 0.05: 9.2 (0.027) for PFUTURES; 8.07 (0.045) for PSOFTRED; 9.04 (0.029) for PFLOUR; 8.96 (0.03) for PCRACKERS; and 9.54 (0.023) for PCAKEMIX. The five tests were run inclusive of the deterministic components restricted to the cointegration space.

recommends implementation of the following four-tiered procedure: one (i) formulates hypotheses that are economically and statistically viable, (ii) tests such hypotheses, (iii) imposes the statistically accepted hypotheses as parameter restrictions, and (iv) re-estimates the two CVs with the imposed restrictions using the Johansen-Juselius reduced rank estimator. Starting with a set of economically and statistically viable restrictions required for the two CVs to comply with the rank condition of identification (TS-1, table 3), one usually implements the four-tiered procedure repeatedly and sequentially until the evidence strongly accepts the cumulative restriction set, offers no substantial further possibilities for testing and inference, and renders a set of finally restricted CVs.

Table 3. Sequential Hypothesis Tests on Beta Estimates: Cointegration Space of U.S. Wheat-Based Markets

Tested restrictions, restriction number.	Explanation, reasoning	Test values, test results, interpretations, analysis of estimates. Fail to reject (i.e. accept) restrictions for p>0.01 (or 0.05)
Test Set-1, TS-1:Identifying restrictions for 2 CVs to comply with rank condition.		
<u>1 on CV1:</u> β(PFUTURES) = 0 <u>3 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0	Identifying conditions from BBP results that US wheat market adjusts/clears independent of direct downstream feedback, but uni-directionally influences downstream markets.	Chi-sq (df=2) = 6.83, p = 0.03. Results: Identifying restrictions accepted at the 3% level. Analysis/new restriction(s) on TS-2: As β(NAFTA) = -β(URUGUAY) on CV2.
Test set-2, TS-2:TS-2 restrictions plus β (NAFTA) = -β(URUGUAY) on CV2.		
<u>1 on CV1:</u> β(PFUTURES) = 0 <u>4 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0 β(NAFTA) = -β(URUGUAY)	See TS-1. See TS-1 for first ; fourth restriction from analysis that β's of NAFTA and URUGUAY about equal and opposite in TS-1 estimation.	Chi-sq(df=3) = 7.16, p = 0.07. Results: Restrictions accepted at the 7% level. Analysis/new restriction(s) on TS-3: CV1, β(PCAKEMIX) = 0, as insig. t-value CV1, β (HIDD0708)=0, as insig.t-value. CV2, β(HIDD0708)=0, as insig. t-value.
Test set-3, TS-3: TS-2 restrictions plus β(PCAKEMIX)=0 andβ(HIDD0708)=0 in CV1;β(HIDD0708)=0 in CV2		
<u>3 on CV1</u> β(PFUTURES)= 0 β(PCAKEMIX) =β(HIDD0708) = 0 <u>5 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0 β(NAFTA) = -β(URUGUAY) β(HIDD0708) = 0	See TS-1 and TS-2 Binaries had insignificant t-values, TS-2. See TS-1 and TS-2. Binary had insignificant t-value, TS-2.	Chi-sq(df=6) = 7.74; p=0.258. Results: Restrictions strongly accepted. Analysis/new restrictions on TS-4): β(TREND)=0 in both CV1 and CV2 as insig. t-values.
Test Set-4, TS-4: TS-3 restrictions plus β(TREND) = 0 in both CV1 and CV2.		
<u>4 on CV1:</u> β(PFUTURES)= 0 β(PCAKEMIX) =β(HIDD0708) = 0 β(TREND) = 0	See TS-1 through TS-3. TREND had insignificant t-value, TS-3.	Chi-sq(df=8) = 7.97, p=0.44 Results: Restrictions strongly accepted.

Table 3. (Continued)

<u>6 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0 β(NAFTA) = -β(URUGUAY) β(HIDD0708) = 0 β(TREND) = 0	See TS-1 through TS-3 Trend had insignificant t-value, TS-3.	Analysis/new restrictions for TS-5: CV1, β(FBILL08) = 0 as insigif. t-value.
Test set-5, TS-5:TS-4 restrictions plus β(FBILL08) = 0in CV2.		
<u>4 on CV1:</u> β(PFUTURES)= 0 β(PCAKEMIX) =β(HIDD0708) = 0 β(TREND) = 0 <u>7 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0 β(NAFTA) = -β(URUGUAY) β(HIDD0708) = 0 β(TREND) = 0 β(FBILL08) = 0	See TS-1 through TS-4. See TS-1 through TS-4 Binary had insignificant t-value, TS-4.	Chi-sq(df=9) = 9.51, p = 0.392. Results: Restrictions strongly accepted. Analysis/new restrictions for TS-6: β(FBILL96) = 0 as insigif. t-value.
Tested restrictions, restriction no.	Explanation, reasoning	Test values, test results, interpretations, analysis of estimates. Fail to reject (i.e. accept) restrictions for p>0.01 (or 0.05)
Test set-6, TS-6:TS-5 restrictions plus β(FBILL96) = 0in CV2.		
<u>4 on CV1:</u> β(PFUTURES)= 0 β(PCAKEMIX) =β(HIDD0708) = 0 β(TREND) = 0 <u>8 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0 β(NAFTA) = -β(URUGUAY) β(HIDD0708) = 0 β(TREND) = β(FBILL08) = 0 β(FBILL96) = 0	See TS-1 through TS-5. See TS-1 through TS-5. Binary had insignificant t-value, TS-5.	Chi-sq(df=10) = 10.55, p = 0.0.394 Results: Restrictions strongly accepted. Analysis/new restrictions for TS-7: β(FBILL02) = 0 as insig. t-value.
Test set-7, TS-7:TS-5 restrictions plus β(FBILL02) = 0in CV2.		
<u>4 on CV1:</u> β(PFUTURES)= 0 β(PCAKEMIX) =β(HIDD0708) = 0 β(TREND) = 0 <u>9 on CV2</u>: β(PFLOUR)=β(PCRACKERS) = β(PCAKEMIX) = 0 β(NAFTA) = -β(URUGUAY) β(HIDD0708) = β(TREND) = β(FBILL08) = β(FBILL96) = 0 β(FBILL02) = 0	See TS-1 through TS-6. See TS-1 through TS-6. Binary had insignif. T-value, TS-6.	Chi-sq(df=11) = 13.16, p = 0.283 Results: Final restrictions strongly accepted at p=0.28, far above 0.01 or 0.05. Analysis/new restrictions for TS-7: No further hypotheses; TS-7 conditions emerge as final set for final reduced rank estimation of equations 6, 7.

Notes. – Beta symbol denotes reduced rank estimates; CV1 denotes first cointegrating relationship normalized on PFLOUR and CV2 denotes the second CV normalized on PSOFTRED.BBP denotes Babula, Bessler, and Payne in references. Degrees of freedom is a term denoted as df, while Chi-sq. denotes hypothesis test values. The p denotes p-values."Level" refers to level of significance. TS refers to test set."As insig. t-value" refers to the β's t-value falling below the absolute 2.6 critical value, suggesting coefficient insignificance at the 5% level, and this serves as the reason for the relevant β zero restriction.

As noted by Juselius (p. 142), it is sometimes possible to infer and make structural economic interpretations from these finally restricted CVs, and in this paper's case, valid policy implications and guidance for U.S. wheat-based markets.Due to considerations of space, each of the tests of the seven sets of restrictions is not discussed in detail; interested readers are referred to table 3.Table 3 documents the seven such hypothesis test sets or TSs that were tested, imposed when statistically accepted, and then used in a re-estimation of the two CVs using the Johansen-Juselius reduced rank estimator.

Ultimately, the imposed restrictions, were strongly accepted: test set-7's chi-square value of 13.16 generated a p-value of 0.283. Since the p-value of 0.283 far exceeds 0.01 and 0.05, then evidence strongly accepts the set of final TS-7 restrictions at both the 1% and 5% significance levels. As a result, TS-7's restrictions were imposed, and CV1 and CV2 re-estimated with the noted reduced rank estimator. These CVs are the result of imposition of the cumulative and statistically supported restrictions of table 3's TS-1 through TS-7.The two finally restricted CVs are presented below in the next section as equations 6 and 7 for discussion, economic interpretation, and policy guidance.

Economic and Policy Discussion: Statistically Supported Restrictions and Cointegration Parameters

Note the following finally restricted cointegrating relations, with coefficient pseudo t-values presented in parentheses:[10]

(6)PFLOUR =	0.68*PSOFTRED	+ 2.0*PCRACKERS	+ 0.28*URUGUAY
	(8.95)	(7.84)	(3.3)
	+ 0.32*NAFTA	-0.24*FBILL96	-0.27*FBILL02
	(-3.45)	(-4.82)	(-4.91)
	-0.50*FBILL08		
	(-4.95)		

(7) PSOFTRED =	0.40*PFUTURES	- 0.329*URUGUAY	+0.329*NAFTA
	(+3.40)	(-2.23)	(+2.23)

CV1 (equation 6) normalized on flour price appears to be a price transmission mechanism for U.S. upstream/downstream soft wheat-based markets that are linked through wheat price. This wheat price, in turn, serves as the normalizing variable in CV2 (equation 7) that appears to be a price discovery relation for the U.S. soft wheat market. Considering the parenthetical t-values in equations 6-7, both CVs display considerable statistical strength and contain substantial economic and policy content that is illuminated below from an analysis of (i) the empirical nature and statistical qualities of the cointegrating parameters that emerged on the endogenous variables on the two finally restricted CVs, and (ii) interpretation of the

[10] As noted in Juselius (pp. 140-142), CV parameters generate pseudo-t values that are distributed differently from Student t-values, and she estimates that the critical absolute value of the CV pseudo-t values is 2.6 for the 5% significance level. Thus, a CV β-estimate's absolute pseudo-t value of 2.6 or greater would be judged as statistically non-zero at the 5% significance level.

coefficients on the permanent shift binary (dummy) variables included in the error correction space. More specifically, each of these two analyses focuses on a comparative assessment on U.S. soft wheat-related markets of the following groups of policies and events (policies/events, (and denoted throughout by the label in bold print):

- *Policies/events with a wheat market focus*(and imputed PSOFTRED effects): This group of policies/events may include selected farm and trade policies. Farm policies could include (among others) levels of wheat farm price support levels and perhaps acreage reduction provisions of the various U.S. farm bills. Trade events/policies may include (among others) U.S. tariff rate quotas or TRQs and AD/CVD orders on U.S. wheat imports, and various U.S. trade agreements such as NAFTA and the Uruguay Round or UR.
- *Policies with a financial/futures market focus* (and imputed PFUTURES effects): This group of policies/events may include (among others) CBOT alterations to its SRW wheat futures contract terms and conditions (TACs) and financial policies such as Federal Reserve actions that alter interest rates, and in turn, wheat storage costs, and conceivably contract settlement prices.

Note that these two groups of policy/event examples are not exhaustive and could include others; they were chosen here for illustrative policy-analytic purposes.

EMPIRICAL ANALYSIS OF COINTEGRATING PARAMETERS FOR POLICY IMPLICATIONS AND GUIDANCE

Two subgroups of policy results are presented in this section: results concerning CV2's parameter estimates focusing on the U.S. soft wheat commodity market, and a group of results combining CV1 and CV2 estimates that focus on comparative policy effects on wheat-based food product prices and wheat-related food price inflation issues.

Discussion: Cointegrating Parameters, Price Discovery Relation (CV2)

Examination of equation 7's β- and α-estimates suggests that PFUTURES and PSOFTRED interact simultaneously to error-correct the system, and hence reflect bi-directional patterns of mutual influence within this CV. This is because PSOFTRED and PFUTURES both generated statistically significant beta and alpha estimates in equation 7, suggesting that both variables endogenously and simultaneously interact by both influencing and in responding to error correction forces (Juselius, ch. 11).[11]In equation 7, the β-estimate of+0.40 on futures price suggests that each percentage change in futures price elicits a similarly-directed, less than proportional, yet solidly significant (t = 3.40) change in wheat price of 0.40%.Following Juselius' (p. 120) insightful discussion on the normalization and proportionality qualities of cointegrating relations, and given the simultaneous relationship

[11]In CV2, t-values on the alpha estimate is -3.8 for PFUTURES and -3.96 for PSOFTRED. As well, CV2 normalized on PSOFTRED results in a t-value of 3.4 for the beta on PFUTURES.

between futures and soft wheat prices noted above, CV2 also implies that each percentage change in soft wheat price elicits a similarly directed and greater than proportional 2.5% change in futures price. While the greater relative responsiveness of futures price to soft wheat price changes than of wheat price to futures price changes is not a surprising qualitative result, CV2's results provide the first empirical indication of this non-symmetry of wheat/wheat futures price response for these two simultaneously interacting soft wheat prices.

Policy implications are obvious. To influence and manage the U.S. soft wheat market through price, farm/trade policies focusing on the soft wheat commodity market are two and a half times more effective than the noted financial/futures market policies/events. The financial/futures market policies are only 40% as effective in such wheat market management as commodity-focused policies/events. Nonetheless, financial/futures market policies and events noted above that manage to change PFUTURES have noticeable and statistically significant soft wheat market impacts.

Discussion: CV1 and CV2 Cointegrating Parameters, and Wheat-Related Food Cost Issues.

Equation 6's statistically strong β-estimate of +0.68 (t=8.95) on soft wheat price suggests that each percentage rise/fall in soft wheat price elicits a 0.68% rise/fall in downstream flour price.

When the above discussed CV2 transmission estimates are concurrently considered with the CV1 price transmission parameters, the price transmission parameters in table 4 are generated or implied that can render empirical comparative assessments of effects of policies/events for U.S. wheat-related food markets and related food cost/inflation issues, reflected here by movements/effects on PFLOUR.

Table 4. Upstream/Downstream Price Transmission Effects of Different Policies/Events

	Policies/Events of Wheat Market Focus: Farm/Trade Levers.	Policies/Events of Financial/Future Market Focus: Speculative Trading, CBOT TAC changes.
Price effect of focus:	*From:1% ΔPSOFTRED*	*From:1% ΔPFUTURES*
Effects on PFLOUR of	+0.68%	+0.27%

For the price transmission relation, table 4's right-hand column suggests that each percentage change in futures price elicits a similarly directed and less than proportional change of 0.27% in flour price.

A comparison of table 2's central and right hand columns' price transmission parameters suggests that commodity-focused policies such as the above noted trade and farm policies that elicit changes in soft wheat price elicit downstream wheat-related product price effects that are more than double the downstream wheat-based price effects of policies/events that focus on financial/futures markets such as rising volumes of speculative wheat futures trading or CBOT contract TAC changes. Three implications of policy guidance emerge:

- The policies/events with a wheat commodity market focus have more than double the percentage effect on, and hence in managing the movements of, wheat-based food price inflation than policies designed to elicit changes in futures market conditions.
- Nonetheless, the right-hand column's estimates further suggest that policies/events of financial/futures market focus do factor into wheat-based food costs and inflation patterns, and have noticeable and statistically strong influences on related wheat-based food prices.
- And third, should a wheat price surge such as during the 2006/2008 or 1993/1996 periods generate concerns over surges in related food costs and inflation, policies designed with a commodity market focus – farm policies such as farm bill wheat price support provisions (among others) and suspension of trade policy levers such as the 1994/95 US TRQs on Canadian wheat and the 2002-2005 U.S. AD/CVD orders on certain imports of Canadian wheat – would likely be more effective in addressing, managing and/or remedying the wheat-based food price increases than manipulating policies with a wheat futures or financial focus.

Analysis of Coefficients on Selected Policy-Specific Binary Variables in the EC Space

Since this study's model was estimated in natural logarithms, Halvorsen and Palmquist's well-known method of interpreting coefficient estimates generated by binary (or dummy) variables was employed here, following Babula, Rogowsky, and Romain. The Halvorsen-Palmquist values (HP values) indicate, in percentage terms, the amount by which the dependent variable was above (for positive coefficients) or below (for negative coefficients) levels during the remainder of the sample.[12]For example, the CV1 coefficient on FBILL96 of -0.24 generated an HP value of -21.3 that suggests that PFLOUR was about 21% lower after the implementation of the 1996 U.S. farm bill (aka, FAIR Act) than before it. Given prior BBP and BRR findings that flour's production costs are heavily influenced by the price of its main input, wheat, such a result is consistent with the FAIR Act's decline in U.S. wheat farm price support levels and farm wheat prices after the end of the 1993-1996 global spike in grain demand and prices.

A result in CV2, the wheat price discovery relation, is of particular interest and displays notable policy insight. The Uruguay Round and NAFTA coefficients suggest that the two trade agreements generated opposing and partially offsetting effects on wheat price. The HP values suggested that wheat price was 39% higher after NAFTA's implementation than before it, and 28% lower after the Uruguay Round's implementation than before it.[13]Rationalization of these opposing wheat price effects should be cased within the following five policies/events that overlapped the implementations of NAFTA and the Uruguay Round (see U.S. International Trade Commission or USITC 1994, 2003; BRR; Glickman and Kantor; U.S.-Canada Joint Grains Commission):

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[12] As noted in Halvorsen and Palmquist for log/log estimations such as that comprising this paper's cointegrated VAR model, one takes e, the base of the natural logarithm; raises it to the power of the binary's β estimate; subtracts 1.0; and then multiplies the result by 100 to render the HP value on that binary's β-estimate.

[13] Note that given the non-linear nature of the H-P calculation, the oppositely signed coefficients on URUGAY and NAFTA, though of equal absolute values, do not imply exactly offsetting effects.

- NAFTA's January, 1994 implementation;
- The UR's January, 1995 implementation;
- Modest increases in U.S. imports of Canadian wheat, starting after NAFTA's implementation, that accounted for no more than 3% of the U.S. market;
- The Clinton Administration's imposition of two temporary tariff rate quota's (TRQs) on certain Canadian-sourced wheat during the year ending September 11, 1995, and
- Occurrence of a global grains/oilseeds demand/price spike from late-1993 through early-1996 that was more coincidental with the NAFTA implementation than the UR implementation.

The higher wheat price after NAFTA may have arisen because the upward wheat price pressures from the concurrent 1993/1996 spike in global grain demand and prices more than offset downward price pressures from post-NAFTA increases in imports of Canadian-sourced wheat – import increases that were modest in volume and accounted for no more than three percent of the U.S. wheat market at their post-NAFTA peak in the early-1990's. (see USITC 1994).Lower wheat prices after the Uruguay Round's implementation occurred slightly before declining prices of grains (including wheat) associated with the 1996 termination of the 1993/1996 global spike in grain prices/demand. Recalling that President Clinton established two temporary TRQs on certain U.S. imports of Canadian wheat as a safeguard to U.S. wheat farmers, the URUGUAY coefficient and HP value suggest that these two TRQs were not effective or successful in shoring up wheat prices after the Uruguay Round's implementation (Glickman and Kantor; Canada-U.S. Joint Grains Commission).The cause of this negative PSOFTRED effect despite the imposition of the two U.S. TRQs is beyond the purview of this study's estimated model. Perhaps the TRQs' quantity limit was not effectively restrictive, or perhaps declining wheat prices associated with the termination of the 1993-1996 global spike in grain demand and prices offset upward price effects of the established two TRQs during the year ending September 11, 1995.Future research on this issue would be well focused.

By needing to case such binary coefficient interpretations in relation to concurrent events other than that for which a binary was defined exposes the well-known limitation of binary variable interpretation and the Halvorsen-Palmquist procedure: the imprecision with which binaries are interpreted. A binary coefficient, its HP value, and its implied effect on the dependent variable, say for CV2's β(NAFTA) on wheat price discussed above, cannot be attributed solely to NAFTA's implementation, but as a sum total effect on wheat price of the NAFTA implementation and of other important concurrent events such as the 1993/1996 spike in world grains demand and prices. Readers should consequently be cautious in interpreting such coefficients, although applying the HP value to a binary variable in a log/log setting has clear contributions to policy-analysis (see BRR).

SUMMARY, CONCLUSIONS AND POLICY INSIGHTS

This paper has accomplished its three goals. This study extended the cited prior research on quarterly U.S. upstream/downstream food product markets that use aggregated all-wheat. In so doing, what is likely the literature's first monthly cointegrated VAR model of U.S. soft wheat-based markets has been provided, and with strong levels of statistical diagnostic adequacy.

This study accomplished the second motivation in its provision of what may be the literature's first model of U.S. upstream/downstream soft wheat markets that includes a futures market linkage. Such is an important model dimension and analytical capability, given increasing current debates concerning the effects on wheat commodity markets and related downstream food product markets of rising volumes of non-traditional, speculative wheat futures trading, and given rising interest in effects of financial/futures market policy reform.

This paper's final goal of extending policy-analytical use of cointegrated VAR modeling --established for commodity/non-commodity markets by Hua and Lambert and Miljkovic, and for U.S. all-wheat product markets in this journal by BRR – was met by application of such policy analyses to the noted U.S. system of food product markets related to soft wheat. The estimated cointegrated VAR model was used to identify effective policies for targeted U.S. product markets related to soft wheat, and to then comparatively and empirically assess the effectiveness of these identified policies in influencing and managing such markets and soft wheat-related food inflation trends. Related to this, the paper has applied a number of cointegrated VAR advancements that are new to agricultural economics, and noted above.

Four major policy analysis insights emerged from this study. First, noted farm and trade policies directly focused on the U.S. soft wheat commodity market have more than double the effectiveness in influencing and managing the U.S. soft wheat market than cited policies with a financial/futures market focus. And while perhaps an expected result qualitatively, that policies/events with a financial/futures market focus are only 40% as effective as noted policies with a commodity focus for soft wheat markets is likely the literature's first empirical indication of such policy effect asymmetry. Nonetheless, the noted policies of futures/financial market focus have clear and statistically strong effects on the U.S. soft wheat market.

Second, noted farm/trade policies focused on the soft wheat commodity market have more than double the effectiveness in influencing and hence in managing downstream prices of U.S. soft wheat products, and in turn, in managing patterns of wheat-related food price inflation than policies/events with a financial/futures market focus. Nonetheless, policies/events with a financial/futures market focus have real and statistically strong effects on related downstream wheat-based food costs.

And third, having followed BRR and having applied Halvorsen and Palmquist's methods in interpreting binary coefficients in a log/log cointegrated VAR setting has yielded added venues for assessing soft wheat-related market impacts of such policies or events as trade agreements, U.S. antidumping/countervailing duty orders and TRQs on Canadian wheat, and U.S. farm bills.

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THE IMPACT OF TRADE OPENNESS ON TECHNICAL EFFICIENCY IN U.S. AGRICULTURE

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ABSTRACT

Stochastic frontier analysis (SFA), used to estimate technical efficiency, is extended to examine the importance of trade openness on technical efficiency for the U.S. agriculture sector. The results indicate that overall trade openness does not have an impact on technical efficiency in US agriculture. Results have not changed when the trade openness was divided into export and import shares. These results indicate that lesser trade protectionism illustrated with an increase in the share of agricultural imports in agricultural GDP had no impact on technical efficiency. An increase in the share of agricultural exports in agricultural GDP did not lead to an increase in technical efficiency.

JEL Codes: D24, F13, Q17.

Keywords: Stochastic frontier analysis; U.S. agriculture; Technical efficiency; Trade openness.

1. INTRODUCTION

The relationship between free trade and productivity and technical efficiency gains has been controversial among trade economists. The sentiment often echoed by promoters of trade liberalization is substantial expectations of productivity gains due to technical efficiency improvements following trade liberalization. This position is nicely summarized by DaniellaMarkheim (2007) of the Heritage Foundation: “Free trade allows a country to compete in the global market according to its fundamental economic strengths and to reap the productivity and efficiency gains that promote long-run wealth and prosperity.” (p.3)

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Other economists, on the other hand, contend this relationship is more complex than what appears at first glance. First, productivity growth is comprised of two mutually exclusive and exhaustive components, technological change (TC) and technical efficiency change (TEC). TC simply represents a shift of the production possibility frontier (PPF) (*i.e.*, TC represents changes to potential output). TEC indicates a country's movement towards or away from the PPF (*i.e*., TEC measures the gap between a country's actual and potential outputs). It has been determined that trade openness may not have the same effect on both TC and TEC: trade typically does not lead to negative TC, but it can give rise to either positive or negative TEC (*e.g.*, Iyer, Rambaldi, and Tang, 2008). This in turn makes the impact of trade on overall productivity (TE and TEC) uncertain and the relationship between trade openness and technical efficiency an empirical question.

There is a lack of consensus regarding the impact of trade liberalization on technical efficiency. According to Rodrik (1992), this lack of consensus arises because there are no systematic theories linking trade policy to technical efficiency. This may be due to the long prevalent Ricardian doctrine of comparative costs which relies on allocative efficiency (*i.e.*, the allocation of domestic resources into sectors where they are most productive). However, one needs to recall that the original case for the gains from trade was developed by Adam Smith (1937) and relied on scale economies via an expanded division of labor within a larger market to lead to overall gains in productivity: "By means of (foreign trade), the narrowness of the home market does not hinder the division of labour in any particular branch of art or manufacture from being carried to the highest perfection. By opening a more extensive market for whatever part of the produce of their labour may exceed the home consumption, it encourages them to improve its productive powers …" (Book IV, Ch. I, p. 415). New trade theorists (Krugman, 1979; 1980) rediscovered scale economies as a rationale for trade, but limited it only to cases of imperfect competition. Under this assumption, "The range of possible outcomes of trade policy then becomes limited only by the analyst's imagination." (Rodrik, 1992, p. 156) Many contributions that followed the original seminal works by Krugman (1979, 1980) strongly support Rodrik's statement (*e.g.,* Helpman and Krugman, 1985; Bernard *et al*., 2003; Melitz, 2003).

Scale economies are not the only argument for trade liberalization made by those favoring increasing trade. Protection is known to lead to higher concentration in the domestic market. The rise of non-competitive market structures under border protection is presumed to discourage improvements in productivity and technical efficiency. On the other hand, liberalization reverses the incentives to concentration by creating a more competitive environment. However, this relationship between market structure and innovation is hotly debated and disputed in industrial organization. The Schumpeterian perspective, for instance, strongly disagrees with the view that competition is conducive to either innovation or cost reducing investment.

Another argument used by proponents of trade liberalization is that inward-oriented regimes and macroeconomic instability go hand-in-hand. Macroeconomic instability often leads output falling below the full-capacity level, further discouraging productivity growth. In addition, the overvaluation of domestic currency and shortages of imported inputs discourage domestic firms from trying to benefit from scale economies via foreign markets. However, these arguments have nothing to do with trade policy *per se* (Sachs, 1987). Sachs maintains countries should change their exchange rate and fiscal policies when technological performance suffers due to mismanagement of macroeconomic policy. Promotion of trade liberalization likely is driven by ideology rather than economics. Indeed, once attention is focused on trade policy, it becomes extremely difficult to argue that liberalization, as a general rule, must have a positive impact on technical efficiency.

The above theoretical uncertainties resulted in empirical studies to identifying the relationship between trade liberalization and, in turn, trade openness and technical efficiency. The introduction of linear programming and frontier approaches enabled researchers to isolate TEC from TC in a comparison of countries. A number of studies examine the effect of outward orientation (trade liberalization) on technical efficiency at the industry or national economy level (*e.g.*, Iyer, Rambaldi, and Tang, 2008; Amiti and Konings, 2007; Fernandes, 2007; Shafaeddin, 2005; Milner and Weyman-Jones, 2003; Pavcnik, 2002; Lall, Featherstone, and Norman, 2000). Unfortunately these findings did not conclusively lend credibility to either proposition: that trade openness does or does not improve technical efficiency. This study addresses the impact of trade openness on technical efficiency in the U.S. agricultural sector and aims to further contribute to this debate.

2. MODEL AND DATA

Stochastic frontier analysis[1] (SFA) has become a popular tool to estimate the relationship between input and output quantities and has been primarily used to estimate the technical efficiency[2] of firms. This method, first proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977), has seen a surge in the past decade with extensions to estimate technical change, efficiency change, and productivity change measures using stochastic frontier analysis (*e.g.*, Greene, 1993; Kumbhakar and Lovell, 2000).

Here SFA, used to estimate technical efficiency, is extended to examine the importance of trade openness on technical efficiency for the U.S. agriculture sector. The Battese and Coelli (1993) SFA model accounts for heterogeneity in the efficiency measures (see Greene, 2004). This methodology has been extended to evaluate half-normal, truncated and gamma efficiency distributions. Further, these models have been extended to evaluate the market-structure-conduct-performance hypothesis (Shaik et al, 2009) using time-series models and the importance of financial risk (Shaik and Mishra, 2010) using gamma simulated maximum likelihood estimation of technical efficiency.

Following Greene (2004) or Shaik et al (2009), a stochastic frontier production function equation and trade equation may be estimated with panel data using a firm's output and technical inefficiency measure, respectively, as endogenous variables. The stochastic frontier model may be represented as:

[1] Alternative methodology has been used in the literature that uses a two-step procedure. In the first step, the efficiency measures are estimated using non-parametric linear programming approach. This is followed by a Tobit model to evaluate the factors affecting the efficiency in the second step. However, the two-step procedure has been the subject of criticism by some researchers since it might be biased due to omitted or left out variables (see Wang & Schmidt, 2002,and Greene, 2004).

[2] The technical efficiency concept introduced by Farrell (1957) is defined as the distance of the observation from the production frontier and measured by the observed output of a firm. In other words, technical efficiency of a firm can be defined as a measure of how well the firm transforms inputs into outputs given technology. Technical efficiency can be estimated by parametric stochastic frontier analysis or non-parametric linear programming approach.

$$y = f(\mathbf{x},\mathbf{D};\beta)\cdot v - u$$
$$u = f(\mathbf{z};\gamma)\cdot\varepsilon \qquad (1)$$

where $\mathbf{x}_{it}$ is a vector of input variables including t, a time trend affecting output; y_{it} $\mathbf{D}$ is a vector of regional dummy variables; β are the input parameter coefficients, $\mathbf{z}$ is a vector of trade openness variables hypothesized to affect technical inefficiency; u ; v_{it} is a random error assumed to be *iid*and normally distributed with mean zero and variance; σ_V^2 ; u_{it} is the technical inefficiency of the firm at time *t* constrained to bepositive and hence is a truncated normally distributed variable with mean zero and variance σ_U^2 ; and ε_{it} is a random error which is normally distributed with mean zero and variance σ_ε^2 .

Equation (1) is used to econometrically estimate two alternative models to evaluate the importance trade openness on technical inefficiency. The first model uses trade openness as the variable explaining technical inefficiency with a Hicks-neutral[3] production function using the aggregate input. The empirical panel stochastic frontier model is represented as:

$$y_{it} = \alpha_1 + \beta_{1,1} AggregateInput_{it} + \beta_{1,2}\, t_{it} + \beta_{1,3} DRegional_{it} + v_{it} - u_{it} \qquad (2)$$

$$u_{it} = \alpha_2 + \beta_{2,1} TOpen_{it} + \varepsilon_{it}$$

where i represents the number of cross-sections (i.e., countries) and t represent the time-series (i.e., number of years).

In order to differentiate the effect of different inputs on agricultural output, the Hicks-neutral production function containing 6 individual or independent inputs along with trade openness in the technical inefficiency equation is estimated. The panel stochastic frontier production function can be represented by a Cobb-Douglas[4] functional form as:

$$y_{it} = \alpha_1 + \beta_{1,1} Capital_{it} + \beta_{1,2} Land_{it} + \beta_{1,3} Labor_{it} + \beta_{1,4} Chemicals_{it} + \beta_{1,5} Energy_{it}$$
$$+ \beta_{1,6} Material_{it} + \beta_{1,7}\, t_{it} + \beta_{1,8} DRegional_{it} + v_{it} - u_{it}$$

$$u_{it} = \alpha_2 + \beta_{2,1} TOpen_{it} + \varepsilon_{it} \qquad (3)$$

[3] Hicks-neutral assumption implies a common technology change is associated with the production function. Non-neutral technical change implies technology is independently associated with each input variable. Both models including Hicks-neutral and non -neutral change were statistically tested and compared. The AIC model selection criteria suggested that there is no statistically significant difference between the two models. Hence we assumed Hicks-neutral technical change due to its more straightforward and convenient interpretation.

[4] A more flexible functional form, the Translog production function was also estimated. The AIC model selection criteria suggested that there is no statistically significant difference between Cobb-Douglas and Translog production function. Due to convenience of interpreting the input elasticities and the returns to scale, we are presenting the results from Cobb-Douglas production function.

State level data[5] for 48 contiguous states over the period, 1973 to 2004 in the U.S. is used in the empirical application. The output is an aggregate quantity index of livestock, crops, other farm outputs. Similarly, the input is an aggregate quantity index of six inputs (capital, land, labor, chemicals, energy and materials). The individual capital, land, labor, chemicals, energy and material inputs are quantity indexes. For details on the construction of the data, refer to http://www.ers.usda.gov/Data/AgProductivity/methods.htm. A time trend, t, is included to capture technology shifts in the frontier over time. Resource regional dummies (DRegion), are included to capture the spatial (U.S. production regional differences) shifts in the frontier. The nine regions used in the analysis are DRegion1 or Northern Crescent (Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Wisconsin); the DRegion2 or Heartland (Illinois, Indiana, Iowa, Missouri, and Ohio); DRegion3 or Norther Great Plains (Nebraska, North Dakota, and South Dakota); DRegion4 or Eastern Uplands (Arkansas, Kentucky, Tennessee, and West Virginia); DRegion5 or Southern Seaboard (Alabama, Georgia, North Carolina, South Carolina, and Virginia); DRegion6 or Mississippi Portal (Louisiana, and Mississippi); DRegion7 or Prairie Gateway (Kansas, Oklahoma, and Texas); DRegion8 or Basin and Range (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming); and DRegion9 or Fruit Rim(California, Florida, Oregon, and Washington). The efficiency effect model contains trade openness (Alcala and Ciccone, 2004) measured as agricultural exports plus agricultural imports divided by agricultural gross domestic product (GDP). All data on agricultural commodities exports and imports[6] and GDP are at the state level and are collected from the ERS, USDA for the period, 1973-2004.

Coefficients on all factor inputs are expected to have a positive sign, *i.e.*, additional input quantities are expected to lead to an increased production level or an outward PPF move. The time variable is expected to have a positive sign indicating an increase in productivity over time. The efficiency equation, being the main target of our interest, contains the trade openness variable. As previouslyelaborated, the sign on the trade openness variable, based on various trade theory arguments, can be positive or negative.

2.1. Results

Equation (2) and (3) are estimated using LIMDEP software that estimates the SFA using maximum likelihood estimation techniques. (for details see LIMDEP, 2007). Both variations of the model presented in equation (2), *i.e.*, efficiency equations containing different representations of the trade openness, have been estimated using log-log specification. Hence results are provided in the form of elasticities. The results are presented in Table 1 and 2 respectively for trade openness and export/import models. The first specification of the model, with aggregate inputs specification in the production function, yields some interesting results.

[5]The author thanks Eldon Ball of ERS USDA for providing the state level datacomprising of 2160 observations covering $N = 48$ states over the $T = 45$ years from 1960 to 2004. Further details concerning the construction of the data can be accessed from Ball, Hallahan and Nehring (2004).

[6]The author thanks Alberto Jerardo of ERS USDAfor providing the state level import data from 1973-2004.

Table 1. Parameter coefficients of production function with aggregate inputs and (agricultural imports + agricultural exports)/GDP as the trade openness measure

	Stochastic	Frontier Production	Function	Equation
	Parameter	Standard Error (SE)	Z-value	P[|Z|>z]
Intercept	2.055	0.064	31.70	0.0000
Trend	0.016	0.0001	142.75	0.0000
AggregateInput	0.632	0.012	50.01	0.0000
DRegion2	-0.113	0.100	-1.13	0.2586
DRegion3	-0.021	0.111	-0.194	0.8462
DRegion4	0.062	0.057	1.086	0.2775
DRegion5	0.034	0.044	0.769	0.4419
DRegion6	0.032	0.251	0.130	0.8966
DRegion7	-0.225	0.155	1.454	0.1460
DRegion8	-0.025	0.029	-0.873	0.3828
DRegion9	0.141	0.070	2.017	0.0436
Trade Openness				
TOpen	0.588	0.662	0.888	0.3747
Variance parameters for compound error				
Lambda	2.073	1.050	1.975	0.0483
Sigma(u)	0.154	0.054	2.845	0.0044

A positive and significant coefficient associated with the time trend suggests a technical change in the agricultural sector during the period under consideration led to an increased output quantity index.

This result is consistent with Antle and Capalbo (1988). Based on the parameter coefficient, a change from one year to the next would lead to approximately 0.02 percent increase in the output index. The aggregate factor inputhas significant impact on the output: a 10 percent increase in the use of all inputs would lead to a 6.32 percent increase in the output. Finally, regional dummies are all equal, statistically speaking, with only the Fruit Rim region experiencing more significant output increases over time than the omitted Northern Crescent region. The significance of lambda and sigma (u) supports the use of SFA (see Greene, 1990 and 2003).

The efficiency equation of this model specification reveals that trade openness has no impact on technical efficiency (although you do not measure the effects of TO on overall outward shifts in the PPF as supported by the time trend coefficient, only the relative distance of individual state aggregates from an expanding PPF). While this result simply states that, for the given data set, a change in agricultural trade openness does not impact technical efficiency in agriculture, the implications of it are more significant. As it was stated earlier, one of the key political motives for trade liberalization is an increase in productivity and technical efficiency. Once that rationale is proved to be redundant, it becomes difficult, from a producers point of view, to justify and promote trade liberalization, unless there are price effects from expanding markets, yielding benefits even without any technical change. Hence this result is likely to fuel the usual argument between trade liberalizers and trade protectionists. To make sure that this result is robust, following Shaik (2007) alternative specification of the model with disaggregate inputs in its production function is tested. The results from this model specification are presented in Table 2.

This model specification confirms the presence of Hicks-neutral technical change. However, the factor input coefficients tell some interesting stories. Four out of six inputs contribute to the output increase over time: land (at 10 percent significance level), and labor, chemicals and material at 1 percent significance level. The contribution of land (adjusted for quality using hedonic pricing approach, USDA http://www.ers.usda.gov/Data/AgProductivity/methods.htm#landinput) is small, as expected: a 10 percent increase in agricultural land leads to an increase in the output by 0.43 percent.

Table 2. Parameter coefficients of production function with disaggregate inputs and (agricultural imports + agricultural exports)/GDP as the trade openness measure

	Stochastic	Frontier Production	Function	Equation
	Parameter	Standard Error (SE)	Z-value	P[|Z|>z]
Intercept	2.368	0.116	21.23	0.0000
Trend	0.012	0.0004	28.54	0.0000
Capital	-0.006	0.020	-0.289	0.7725
Land	0.043	0.025	1.674	0.0941
Labor	0.070	0.011	6.494	0.0000
Chemicals	0.077	0.008	10.145	0.0000
Energy	-0.003	0.013	-0.200	0.8418
Materials	0.390	0.013	29.701	0.0000
DRegion2	-0.189	0.118	-1.605	0.1041
DRegion3	-0.116	0.117	-0.991	0.3216
DRegion4	-0.046	0.080	-0.570	0.5686
DRegion5	-0.054	0.047	-1.146	0.2517
DRegion6	-0.097	0.203	-0.476	0.6338
DRegion7	-0.344	0.144	-2.385	0.0171
DRegion8	-0.125	0.053	-2.362	0.0166
DRegion9	-0.015	0.164	-0.090	0.9286
Trade Openness				
TOpen	0.688	0.743	0.926	0.3544
Variance parameters for compound error				
Lambda	2.339	1.344	1.740	0.0818
Sigma(u)	0.171	0.064	2.663	0.0078

Most productive agricultural land has long been in use, and adding marginal, less productive land would only marginally increase the output. The substitution of labor for other factor inputs has taken place for several decades in the 20th century. This model indicates a very inelastic PPF response to the change in labor use, *i.e.*, a 10% increase in labor use leads to an increase in the output by 0.7 percent.

Even if inelastic, this response is somewhat unexpected considering that agriculture had, throughout the 20th century, experienced constant movement of rural population into the cities due to relative wage differences. It is likely that resulting rural over-depopulation then led to the lack of farm labor in a number of states, in particular where labor intensive agriculture (*e.g.*, vegetable and fruit industries) is dominant. This leads to some, however minimal, opportunities to increase the output by increasing the labor use. Results indicate a very inelastic PPF response to changes in chemicals use, *i.e.*, a 10% increase in labor use leads to an increase in the output by 0.77 percent.

One input factor whose increase would lead to a more significant PPF response is materials: a 10% increase in materials use leads to an increase in output by 3.9 percent. Finally, this model specification also suggests minimal variation in output across the regions. These input elasticity results of the production function are generally consistent with the results from Shaik and Mishra (2010) using the same data. Differences may arise due to the time-period used in the analysis.

This model specification also indicates that overall trade openness is not statistically significant in its impact on technical efficiency. This result is consistent with the result in the first model and confirms the robustness of the previous finding. Trade openness does not seem to be justifiable from US agricultural producers' standpoint and hence cannot be used in promoting free trade. In order to fully confirm this finding, we disaggregated trade openness into two components to create two alternatives and possibly more informative measures: the agricultural exports divided by the agricultural gross domestic product, and the agricultural imports divided by the agricultural gross domestic product.

3. Disaggregating Trade Openness

It is possible that more (less) protection in imports may have a positive (negative) impact on technical efficiency. This proposition stems directly from some of the premises of the new trade theory. Krugman (1984) suggested in his model of "import protection as export promotion" that protectionist policies (assuming that increasing returns to scale takes the form of decreasing marginal costs) allow home firms to increase their domestic sales and therefore to reduce their marginal costs. In turn, the home firms with lower marginal costs can become more competitive in world markets, and therefore increase their exports as well.

Even though the United States is perceived as a champion of free trade, there is an ample history of protectionist policies in agricultural trade, including well documented direct measures such as import tariffs, import quotas, or import licenses (*e.g.* Knutson, Penn, and Flinchbaugh, 1998; Miljkovic, 2004), and indirect measures such as sanitary and phytosanitary regulations (*e.g.*, Miljkovic, 2005).

Some recent US trade protectionist policies include side agreements of the North American Free Trade Agreement (NAFTA) to accommodate and protect domestic farmers.[7] Hence testing the impact of import protection in agricultural trade on the technical efficiency of the agricultural sector in the United States is appropriate.

Agricultural commodity export promotion policies in the United States have a long-standing history. They have traditionally been employed to help develop foreign markets (Miljkovic, 2004). Yet, their impact on both productivity and technical efficiency has not been analyzed. It is possible that exposure to competition in new markets would force US producers to become more efficient. In order to help resolve these issues, trade openness is divided into import and export shares and their impact on technical efficiency is measured. Given the correlation coefficient between agriculture import and exports is -0.277, it would be appropriate to include both variables simultaneously as proxies for trade openness to avoid the omitted variable bias.

Econometric specification is equivalent to one in equations (2) and (3) with only change being that agricultural exports and agricultural imports share in agricultural GDP was substituted for trade openness:

$$y_{it} = \alpha_1 + \beta_{1,1}AggregateInput_{it} + \beta_{1,2}\, t_{it} + \beta_{1,3}DRegional_{it} + v_{it} - u_{it} \tag{2a}$$

$$u_{it} = \alpha_2 + \beta_{2,1}ExpShare_{it} + \beta_{2,2}ImpShare_{it} + \varepsilon_{it}$$

$$y_{it} = \alpha_1 + \beta_{1,1}Capital_{it} + \beta_{1,2}Land_{it} + \beta_{1,3}Labor_{it} + \beta_{1,4}Chemicals_{it} + \beta_{1,5}Energy_{it} + \beta_{1,6}Material_{it} + \beta_{1,7}\, t_{it} + \beta_{1,8}DRegional_{it} + v_{it} - u_{it}$$

$$u_{it} = \alpha_2 + \beta_{2,1}ExpShare_{it} + \beta_{2,2}ImpShare_{it} + \varepsilon_{it} \tag{3a}$$

3.1. Results

Results from the models described in equations (2a) and (3a) are presented in tables 3-4.

Results from the models containing the share of agricultural imports in agricultural GDP and share of agricultural exports in agricultural GDP as a measure of trade openness are consistent with the results of the aggregate trade openness model.

Increasing (lowering) the protection and thus leading to a growing (declining) share of the agricultural imports and/or agricultural exports in agricultural GDP has no impact on technical efficiency in agricultural production.

Other results, *i.e.*, the impact of input factors, time trend and regional considerations, are also consistent with the aggregate trade measure model. While benefits to consumers stemming from trade liberalization are obvious and well documented, domestic producers do not seem to react and make an adjustment to an increase in foreign competition.

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[7] Side agreements following the signing of NAFTA on the imports of tomatoes, orange juice, sugar, or environmental standards are among those illustrating this point. For example, during the heat of the 1996 presidential election, the Clinton administration yielded to the demands of Florida tomato interests by negotiating a floor price on tomatoes imported from Mexico. Mexico's agriculture minister objected to the pact by indicating that this new barrier to trade would damage Mexico's producers and would cost jobs in a country already plagued by unemployment. (Knutson, Penn, and Flinchbaugh, 1998)

Table 3. Parameter coefficients of production function with aggregate inputs and agricultural imports/GDP and agricultural exports/GDP as the trade openness measure

	Parameter	Standard Error	Z-value	P[|Z|>z]
	Stochastic Frontier Production Function			
Intercept	2.0743	.065	31.44	.0000
Aggregate Input	.6277	.012	49.24	.0000
Trend	.0162	.000	144.32	.0000
DRegion2	-.1227	.042	-2.86	.0041
DRegion3	-.0314	.060	-.52	.6004
DRegion4	.0592	.046	1.27	.2023
DRegion5	.0350	.051	.67	.4998
DRegion6	.0296	.179	.16	.8687
DRegion7	-.2294	.122	-1.88	.0600
DRegion8	-.0240	.033	-.72	.4675
DRegion9	.1405	.069	2.02	.0428
	Trade Openess			
TExports/GDP	-3.330	2.162	-1.540	.1235
TImports/GDP	.633	.841	.753	.4516
	Variance parameters for compound error			
Lambda	3.770	4.613	.81	.4138
Sigma(u)	.281	.176	1.59	.1119

There may be a couple of possible explanations for these outcomes. First, the domestic (US) market also grew substantially during this period in terms of its population, purchasing power, and diversity. Shear market size may have allowed an increased foreign presence in the United States without impacting the sales and profitability of domestic producers. Moreover, with added demographic diversity, the domestic market became more segmented.

Many varieties of agricultural commodities consumed by an increasing proportion of first and second generation of immigrants of various ethnic groups in the United States have not traditionally been produced domestically hence opening the door for the imports. Second, US has always had a conflicting approach to trade policy and farm policy by championing free trade via export enhancement and foreign market development programs while simultaneously providing significant protection to farmers via both price and income farm policies (Miljkovic, 2004; Knutson, Penn, and Flinchbaugh, 1998).

These protectionist farm policies may have ensured comfortable access to domestic markets while at the same time trade policies ensured foreign market access without an actual need for an increase in technical efficiency relative to competitor nations. Finally, productivity increase in agriculture in recent decades stemmed primarily from biotech and chemical industry producing inputs for agricultural production. These companies, either American, European, or multinational, have an interest in disseminating their new products and technologies globally hence making them available to all agricultural producers around the world. It is then not obvious how American agricultural producers would increase their technical efficiency due totrade liberalization more than agricultural producers elsewhere and become more competitive internationally, even if technologies originated in the United States.

Table 4. Parameter coefficients of production function with disaggregate inputs and agricultural imports/GDP and agricultural exports/GDP as the trade openness measure

	Parameter	Standard Error	Z-value	P[|Z|>z]
	Stochastic Frontier Production Function			
Intercept	2.415	.115	20.87	.0000
Capital	-.006	.019	-.31	.7516
Land	.036	.025	1.41	.1584
Labor	.069	.009	7.03	.0000
Chemicals	.074	.007	10.12	.0000
Energy	-.002	.013	-.19	.8492
Materials	.389	.012	30.71	.0000
Trend	.011	.000	30.32	.0000
DRegion2	-.193	.065	-2.97	.0029
DRegion3	-.118	.065	-1.79	.0733
DRegion4	-.043	.067	-.64	.5195
DRegion5	-.053	.052	-1.02	.3045
DRegion6	-.095	.156	-.61	.5397
DRegion7	-.342	.120	-2.83	.0046
DRegion8	-.120	.065	-1.83	.0665
DRegion9	-.012	.169	-.07	.9400
	Trade Openess			
TExports/GDP	-2.830	2.044	-1.385	0.166
TImports/GDP	0.675	0.998	0.676	0.499
	Variance parameters for compound error			
Lambda	4.162	5.136	0.810	0.418
Sigma(u)	0.304	0.183	1.657	0.098

CONCLUSIONS AND IMPLICATIONS

The impact of trade liberalization on productivity and technical efficiency has been a point of scholarly debate for decades. The lack of a clear and transparent theory leading to a unique resolution of the issue led the profession down the path of empirical studying of the problem. This study was conducted in that spirit.

The results of this study indicate that overall trade openness does not have an impact on technical efficiency in US agriculture. Results have not changed when the trade openness was divided into export and import shares. These results indicate that lesser trade protectionism illustrated with an increase in the share of agricultural imports in agricultural GDP had no impact on technical efficiency. An increase in the share of agricultural exports in agricultural GDP did not lead to an increase in technical efficiency.

Substantial resources have been spent in the United States throughout the last several decades trying to ensure barrier free access of domestic producers to international agricultural markets. The Uruguay Round of GATT negotiations and subsequent WTO negotiations are most recent and telling examples of such efforts. The US also engaged in a variety of regional trade agreements such as CUSTA and NAFTA. These negotiations were often motivated by the claim of free trade leading to increased productivity and technical efficiency in US agriculture. Given that this underlying motive for free trade does not exist based on our results, the answer to the questions: Is the cost of free trade negotiation, from an agricultural producers point of view, justifiable?; and, who should bear it?, would be no, and not the agricultural producers.

There are two important caveats to be made. First, our discussion assumes that protection/liberalization completely explains changes in trade openness. Fact is that changes in imports/exports are often a result of changes in exchange rate and other macroeconomic factors and policies in both the United States and abroad as well as in national trade policies among US trading partners. Second, we do not measure the impact of trade openness on overall PPF movement. It is possible that an increase in exports and thus in trade openness is contributing to an outward PPF shift**.** In other words, there may be price effects from expanding markets, yielding benefits to producers even without any technical change thus justifying their support of the free trade negotiations.

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UNDERSTANDING MEXICAN MEAT CONSUMPTION AND IMPORTS AT THE TABLE CUT LEVEL

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ABSTRACT

Current and forecasted Mexican meat consumption and imports are estimated at the table cut level of disaggregation. Unlike previous studies, this study uses adult equivalence scales, a price imputation approach, a consistent censored demand system, and estimation techniques from stratified sampling theory to provide an analysis of current and future trends of table cuts of meats. The results indicate that most Mexican consumption and imports of table cuts of meats grow at different rates. In addition, Mexico seems to be following the U.S. preferences for beef cuts, but not for chicken cuts. The study can be used by U.S. and Canadian meat exporters to forecast future exports to Mexico, conduct long-term investment decisions in the meat industry, or identify likely trends in consumption and trade of specific table cuts of meats.

JEL codes: R21, Q11.

Keywords: censored demand system, consumption, elasticities, forecast, imports, stratified sampling, table cut level, two-step estimation.

INTRODUCTION

The Mexican meat market is very important for U.S. and Canadian meat exporters because it is relatively large and rapidly expanding, it has a high preference for edible meat offal, and Mexican per capita meat consumption still remains low compared to the equivalents in the United States and Canada. A better understanding of Mexican meat consumption will benefit U.S. meat exporters, policy makers, and researchers to appropriately

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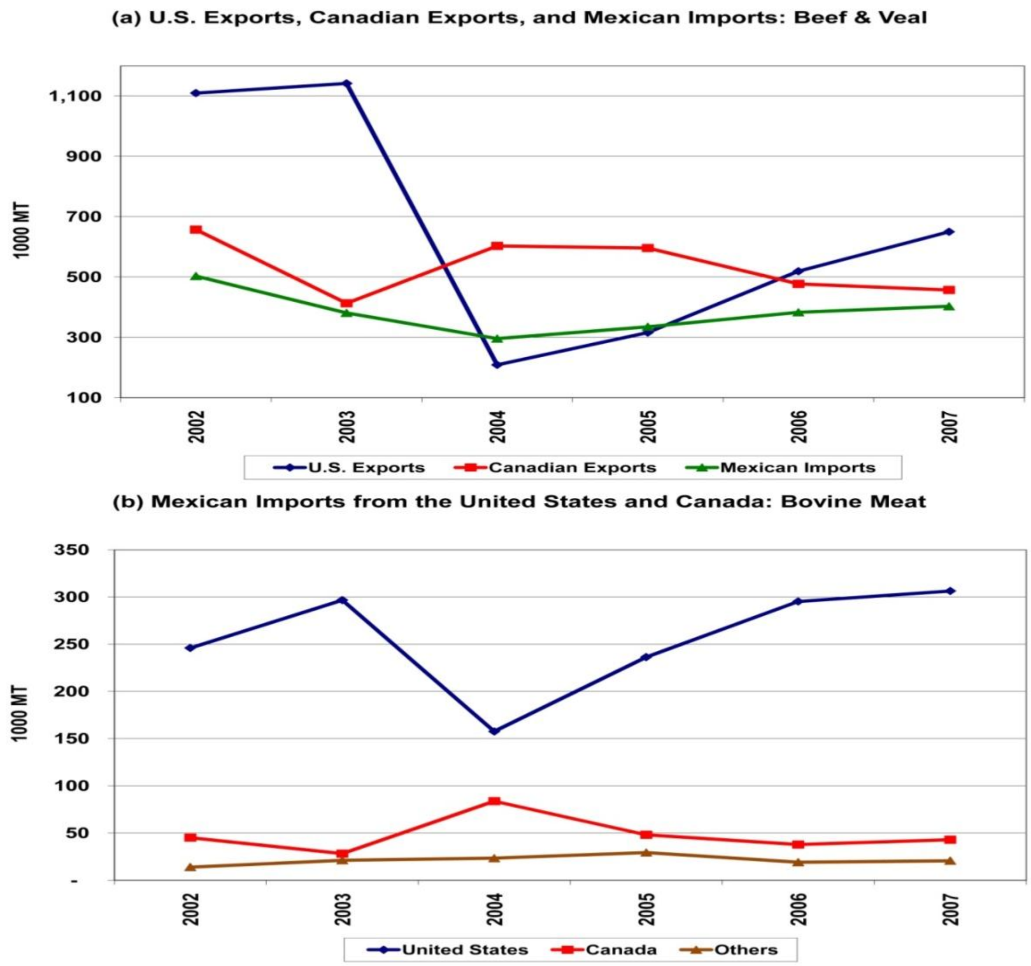
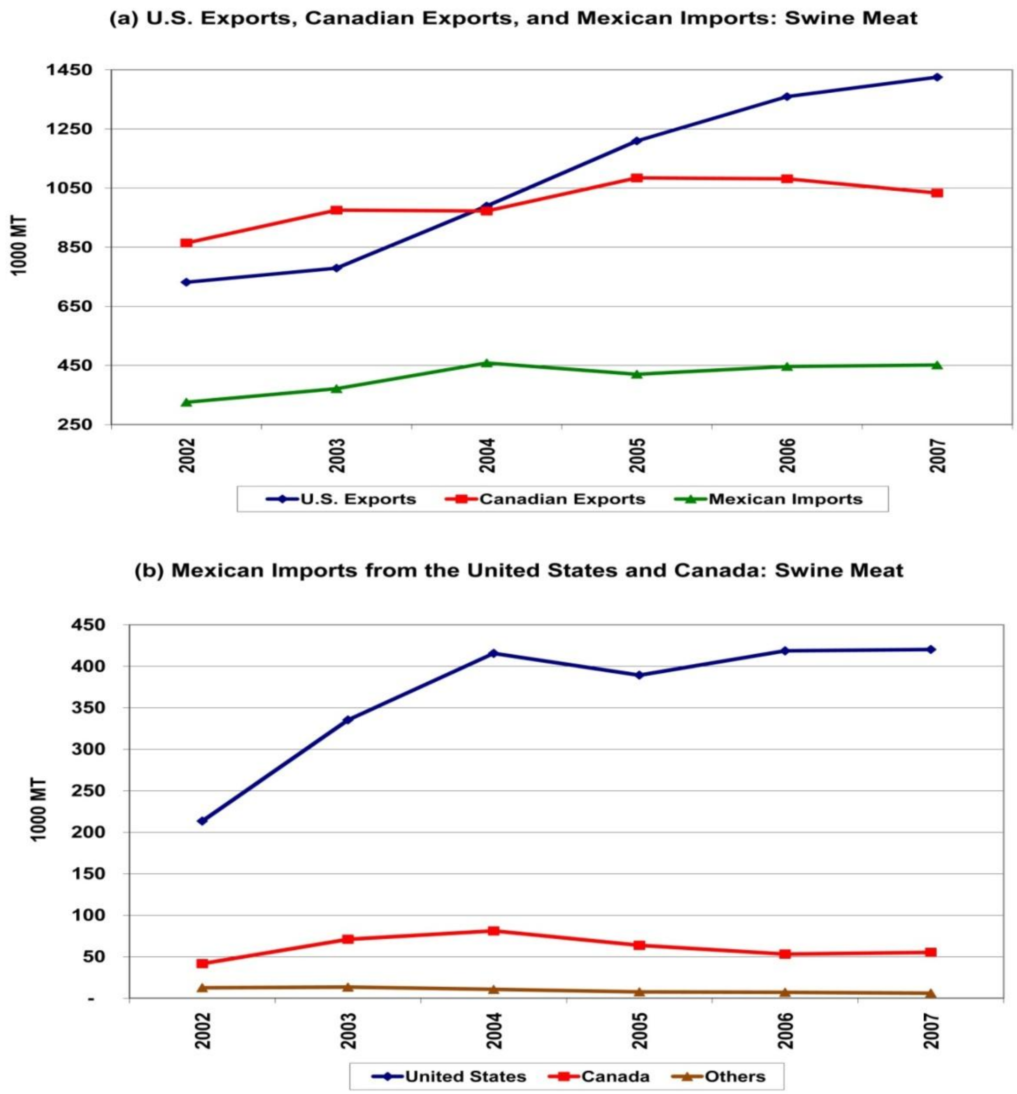
comprehend Mexican consumers' response to price changes, current and future trends and growth rates in specific table cuts of meats, current and future structure of Mexican meat consumption and imports, and the nature of Mexican meat preferences for a specific table cut of meat.

The volume of beef and veal, swine meat, and poultry meat the United States and Canada export is highly correlated to the volume of these meats that Mexico imports (panels (a) in figures 1, 2, and 3).



Source: Panel (a) from USDA-ERS-PSD Online Database. Panel (b) from Mexican Secretariat of Economy, SIAVI Database.Charts computed by authors.

Figure 1. Bovine meat trade. Note: Series in Panel (b) were computed from chapter 2 (meat and edible meat offal) of the Harmonized System. Bovine meat is the sum of bovine meat carcasses and half-carcasses, other bovine meat cuts with bone-in, boneless bovine meat and edible bovine offals. At the 8-digit level of disaggregation, bovine meat carcasses and half-carcasses include commodities 02011001 and 02021001. Other bovine meat cuts with bone-in include commodities 02012099 and 02022099. Boneless bovine meat includes commodities 02013001 and 02023001. Edible bovine offals include commodities 02061001, 02062101, 02062201 and 02062999. All years are calendar years (January to December) except for 2002, which was reported from April to December.



Source: Panel (a) from USDA-ERS-PSD Online Database. Panel (b) from Mexican Secretariat of Economy, SIAVI Database.Charts computed by authors.

Figure 2. Swine meat trade. Note: Series in Panel (b) were computed from chapter 2 (meat and edible meat offal) of the Harmonized System. Swine meat is the sum of swine carcasses and half-carcasses; swine hams, shoulders and cuts thereof, with bone-in; boneless swine meat; and edible swine offals. At the 8-digit level of disaggregation, swine meat carcasses and half-carcasses include commodities 02031101 and 02032101. Swine hams, shoulder and cuts thereof, with bone-in include commodities 02031201 and 02032201. Boneless swine meat includes commodities 02031999 and 02032999. Edible swine offals include commodities 02063001, 02063099, 02064101, 02064901 and 02064999. All years are calendar years (January to December) except for 2002, which was reported from April to December.

This is due in part because Mexico currently imports most of its meat from the United States and Canada (panels (b) in figures 1, 2, and 3). For instance, from 2002 to 2007, 79%, 84%, and 92% of the total volume of Mexican imports of bovine meat, swine meat, and chicken respectively, came from the United States. On the other hand, during the same period, U.S. meat exports to Mexico represented 50%, 34%, and 12% of the total volume of U.S. exports of beef and veal, swine meat, and poultry meat respectively. This makes Mexico among the three largest U.S. export markets for either beef, pork and chicken (Salin, Hahn, and Harvey 2002; and Salin 2002).

The Mexican meat market is also rapidly expanding. Mexican swine meat imports grew 449%, from 82,000 metric tonnes (MT) in 1997 to 450,000 MT in 2006 (United States Department of Agriculture (USDA)). In addition, Mexican poultry meat imports went from 283,000 MT in 1997 to 590,000 MT in 2006 (a growth rate of 108%); while the beef imports went from 203,000 MT in 1997 to 365,000 MT in 2006 (a growth rate of 80%) (USDA).

A descriptive analysis of Mexican imports at the 8-digit disaggregation level of the harmonized system shows that the most imported bovine meats are boneless bovine meats and edible bovine offals. From 2002 to 2007, these meats average 74% and 22% of the total volume of bovine meat imports respectively (Mexican Secretariat of Economy). Imports of other bovine meat cuts with bone-in, ham and bacon and similar products from bovine meat, and bovine meat carcasses and half-carcasses average 2%, 1%, and 0.3% respectively.For swine meat, the most imported cuts are swine hams, shoulders and cuts thereof with bone-in, averaging 40% of total volume of swine meat imports.

Edible swine offals, boneless swine meat, ham and bacon and similar products from swine meat, and swine meat carcasses and half-carcasses account for 32%, 16%, 9% and 4% of the total volume of swine meat imports respectively. In the case of chicken, the most imported cuts are boneless chicken, and chicken legs and thighs, averaging 46% and 33% of the total volume of chicken imports respectively. The remainder is represented by other chicken cuts and chicken offals (17%), whole chicken (3%), and chicken ham and similar products (1%).

These results indicate that the Mexican meat market has a relatively high preference for edible meat offal. Imports of edible bovine offals are larger than imports of bovine meat carcasses and half-carcasses, other cuts of bovine meat with bone-in, and ham and bacon and similar products from beef (Mexican Secretariat of Economy). Similarly, imports of edible swine offals are larger than imports of swine meat carcasses and half-carcasses, boneless swine meat, and ham and bacon and similar products from swine meat (Mexican Secretariat of Economy). In the case of chicken, chicken offal imports are larger than whole chicken imports and chicken ham and similar products (Mexican Secretariat of Economy).

The Mexican meat market is also important because its per capita meat consumption still remains low compared to the equivalent in the United States and Canada. For instance, from 1997 to 2006, Mexico averaged a per capita meat consumption of 60.78 kg while the United States and Canada averaged 121.61 and 98.38 kg respectively (USDA and International Monetary Fund). Given that the Mexican meat market is rapidly expanding, this suggests that Mexican per capita meat consumption could continue growing, making Mexico an important international market for years to come.

Given the high importance of the Mexican meat market for U.S. and Canadian meat exporters, the objective of the study is to use a theoretically sound research approach to provide an in-depth analysis of the Mexican meat market that estimates demand elasticities at the table cut level, and identifies current and future likely trends in consumption and trade.

The study can be used by U.S. and Canadian meat exporters to forecast future exports to Mexico, conduct long-term investment decisions in the meat industry, or identify likely trends in consumption and trade of specific table cuts of meats. Furthermore, the study contributes to the existing literature on demand analysis in many ways.

First, unlike previous studies that estimate Mexican meat demands at the aggregate level, such as beef, pork, and chicken (Henneberry and Mutondo 2009; Erdil 2006; Malaga, Pan, and Duch-Carvallo 2006; Dong, Gould, and Kaiser 2004; Gouldetal. 2002; Gould and Villarreal2002;Golan, Perloff, and Shen 2001; Sabates, Gould, and Villarreal 2001; DongGould2000; Garcia Vega and Garcia2000; andHeien, Jarvis, and Perali 1989), the present study estimates meat demands, and identifies trends in meat consumption and imports at the table cut level (i.e., beefsteak, ground beef, pork steak, ground pork, chicken legs and thighs and breasts, fish, etc.), which is more appropriate in terms of consumer choices. Second, the study uses the entire target population rather than a segment that may not be representative (e.g., Malaga, Pan, and Duch-Carvallo2006;Dong, Gould, and Kaiser2004;and Gould et al. 2002).

Third, the study incorporates scales to compute the number of adult equivalents rather than ignoring or using a simple count or proportion of household members (e.g., Malaga, Pan, and Duch-Carvallo 2006; Dong, Gould, and Kaiser 2004; and Golan, Perloff, and Shen2001). Adult equivalence scales are used to compute the number of adult equivalents per households and take into account how much an individual household member of a given age and gender contributes to household expenditures or consumption of goods relative to a standard household member.[1] Fourth, it adjusts for censored observations by using a price imputation approach to account for censored prices, and a censored demand system to account for censored quantity.

As in Malaga, Pan, and Duch-Carvallo (2006), a regression imputation approach is adopted for each of the eighteen meat cuts considered in this study. In particular, non-missing prices of each meat cut is regressed on monthly household income, education level of the household decision maker, regional dummy variables, stratum dummy variables, the number of adult equivalents, a dummy variable for car, and a dummy variable for refrigerator.[2]

A price imputation approach is preferred over a substitution of the missing price with the corresponding simple average of non-missing prices within each Mexican state and strata (e.g., Golan, Perloff, and Shen2001,p. 545;and Dong, Shonkwiler, and Capps 1998, p.1099).[3] The consistent censored demand system of Shonkwiler and Yen (1999) is combined with estimation techniques from stratified sampling theory to account for censored quantities.

Taking into account censored observations is critical for analyzing meat consumption at the table cut level. Censoring generates missing prices and zero quantities from those meat cuts that the households did not buy during the week of interview. In this article, this was the result of the way and time frame in which the survey source collected the data.

[1] This study uses the National Research Council's recommendations of the different food energy allowances for males and/or females during the life cycle, as reported in Tedford, Capps, Havlicek(1986), to compute per adult-equivalent consumption.

[2] Each regression incorporates the stratification variables strata and weight (see SAS Institute Inc. 2004, pp. 4363−4418.

[3] If the latter procedure is adopted, using four strata and Mexico's 31 states plus the Federal District will only provide 128 different values for price imputation and using two strata will only provide 64 different values

MODEL

Following Shonkwiler and Yen (1999) and Su and Yen (2000), a censored system of demand equations for meat is estimated at the table cut level, taking into account the sample stratification issues. The demand equation of household h for meat cut i in the censored system is

$$q_i(h) = \Phi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i]\mathbf{x}_i'(h)\boldsymbol{\beta}_i + \delta_i\varphi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i] + \xi_i(h)\ i = 1, \dots, M, 9 \quad (1)$$

where $\Phi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i]$ is the standard normal cumulative distribution function (cdf) evaluated at $\mathbf{z}_i'(h)\boldsymbol{\alpha}_i$, $\varphi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i]$ is the standard normal probability density function (pdf) evaluated at $\mathbf{z}_i'(h)\boldsymbol{\alpha}_i$, $\mathbf{z}_i'(h)$ and $\mathbf{x}_i'(h)$ are vectors of explanatory variables [4], $\boldsymbol{\alpha}_i$ and $\boldsymbol{\beta}_i$ are vector of parameters, δ_i is a parameter, $\xi_i(h)$ is a random error, and M is the number of meat cuts considered.

Equation (1) is estimated in two steps. First, we obtain maximum-likelihood probit estimates $\widehat{\boldsymbol{\alpha}}_i$ using the binary dependent variable $d_i(h)$ = 1 if $q_i(h)$> 0 and $d_i(h)$ = 0 otherwise. That is, estimate the following probit models by maximum likelihood

$$\mathrm{P}[d_i(h) = 1|\mathbf{z}_i(h)] = \Phi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i], i = 1, \dots, M. \quad (2)$$

However, to incorporate the survey weight variable into the analysis, we multiply the contribution of each observation to the likelihood function by the value of the weight variable.[5]

Second, we calculate $\Phi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i]$and $\varphi[\mathbf{z}_i'(h)\boldsymbol{\alpha}_i]$ and simultaneously estimate the following demand equations,

$$q_i(h) = \Phi[\mathbf{z}_i'(h)\widehat{\boldsymbol{\alpha}}_i]\mathbf{x}_i'(h)\boldsymbol{\beta}_i + \delta_i\varphi[\mathbf{z}_i'(h)\widehat{\boldsymbol{\alpha}}_i] + \xi_i(h), i = 1, \dots, M, \quad (3)$$

by using Zellner's (1962) seemingly unrelated regression (SUR) procedure. To incorporate the survey weight variable into the analysis, all the observations are weighted by the weight variable prior to estimation. The resulting weighted estimator is consistent in stratified samples (Wooldridge 2001, p. 464). According toLohr (1999, p. 355), the standard errors of the parameter estimates obtained above are incorrect and should be ignored. In this article, the standard errors are estimated using a nonparametric bootstrap procedure (see Cameron and Trivedi2005, p. 360). Lohr (1999, pp.289-318) explains several methods for approximating standard errors in complex surveys. However, the bootstrap method is easy to implement and may be equivalent to linearization (Taylor Series) methods for large samples(Lohr1999,p. 314).

Once the system of demand equations is estimated, Marshallian price elasticities and meat expenditure elasticities are computed from

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[4] As in Su and Yen (2000), the vectors $\mathbf{z}_i'$ and $\mathbf{x}_i'$ have common explanatory variables, which in this study consist of all the meat-cut prices (p_i, i = 1, …, 18), regional dummy variables (Northeast, Northwest, Central-West, Central, and Southeast), and urbanization level dummy variables (urban and rural).

[5] See SAS Institute Inc. (2004, p. 3754).

$$\hat{e}_{ij}(h) = \frac{\partial \hat{q}_i(h)}{\partial x_{ij}(h)} \times \frac{x_{ij}(h)}{\hat{q}_i(h)},$$
$$\hat{e}_i(h) = \frac{\partial \hat{q}_i(h)}{\partial x_{ij}(h)} \times \frac{x_{ij}(h)}{\hat{q}_i(h)}, \tag{4}$$

where $\hat{q}_i(h)$ estimates $q_i(h)$ in equation (3), $x_{ij}(h)$is a common variable in $\mathbf{x}_\mathrm{i}(h)$ and $\mathbf{z}_\mathrm{i}(h)$, and

$$\frac{\partial \hat{q}_i(h)}{\partial x_{ij}(h)} = \Phi[\mathbf{z}_\mathrm{i}'(h)\widehat{\boldsymbol{\alpha}}_\mathrm{i}]\hat{\beta}_{ij} + \mathbf{x}_\mathrm{i}'(h)\widehat{\boldsymbol{\beta}}_\mathrm{i}\varphi[\mathbf{z}_\mathrm{i}'(h)\widehat{\boldsymbol{\alpha}}_i]\hat{\alpha}_{ij} - \hat{\delta}_i[\mathbf{z}_\mathrm{i}'(h)\widehat{\boldsymbol{\alpha}}_\mathrm{i}]\varphi[\mathbf{z}_\mathrm{i}'(h)\widehat{\boldsymbol{\alpha}}_\mathrm{i}]\hat{\alpha}_{ij}. \tag{5}$$

These elasticities are evaluated using sample means of explanatory variables, which are computed incorporating the variables strata and weight in stratified samples.These elasticities are then used to perform forecasts and simulation analysis.

DATA

Mexican data on household income and weekly expenditures was obtained from *EncuestaNacional de Ingresos y Gastos de los Hogares (2006)*, which is a nation-wide survey encompassing Mexico's 31 states plus one Federal District (a territory which belongs to all states). ENIGH is a cross-sectional data sample published since 1977 (e.g., see Heien, Jarvis, and Perali1989) by a Mexican governmental institution (*InstitutoNacional de Estadística, Geografía e Informática* (INEGI)).

ENIGH is as a stratified sample, which is different from a random sample. In stratified sampling the population is divided into subgroups (strata) and a simple random sample is taken from each stratum (Lohr 1999, p. 24).

In ENIGH 2006, stratum 1 consists of household locations with a population of 100,000 people or more, stratum 2 consists household locations with a population between 15,000 and 99,999 people, stratum 3 consists of household locations with a population between 2,500 people and 14,999 people, and stratum 4 consists of household locations with a population of less than 2,500 people. These subgroups are often of interest to the investigator because households from the same stratum tend to be more similar than randomly selected households from the whole population. In ENIGH 2006, the sampling weight is the number of units in the population represented by the observed unit that is selected from a stratum. It is the number of households nationally represented by the interviewed household.[6]

Ignoring stratification variables (e.g., weight and strata) as in Malaga, Pan, and Duch-Carvallo (2006), Dong, Gould, and Kaiser (2004), Gouldetal. (2002), Gould and Villarreal (2002), Golan, Perloff, and Shen (2001), Sabates , Gould, and Villarreal (2001), Dong and Gould (2000), Garcia Vega and Garcia (2000), and Heien, Jarvis, and Perali (1989)may result in parameter estimates that are not representative of the population or that may not capture potential differences among the sub-populations (Lohr 1999, pp. 221-254).

In addition, estimating standard errors of parameter estimates in complex surveys is different and more difficult than estimating them in simple random samples. Applying the same procedure results in incorrect estimates (Lohr1999, pp. 289−318 and 347−378); therefore, this study estimates standard errors of parameter estimates by using a

[6] INEGI recommends incorporating stratification variables when using ENIGH (INEGI, personal communication).

nonparametric bootstrap procedure (see Cameron and Trivedi2005, p. 360 or SAS Institute Inc.)[7]

In ENIGH, the data is collected from households for one week by performing direct interviews through a stratified sampling method. During this week of interview, data on food, drinks, cigarettes and public transportation is recorded only when the household makes a purchase. This generates a missing price and a zero quantity for those meat cuts that the households did not buy during the week of interview.

Table 1 shows the number of non-missing and missing observations, as well as the average prices in 2006 Mexican pesos per kilogram (pesos/kg) of the eighteen meat cuts considered in this study before and after price imputation. The mean before price imputation is computed from the non-missing observations only while the mean after price imputation is computed from both non-missing and imputed (i.e., originally missing) observations. Table 2 reports the average per capita consumption per week (kg) of the eighteen meat cuts considered in this study.[8] The high number of censored observations is common in household surveys where meat is analyzed at the disaggregated level (see Taylor, Phaneuf, Piggott 2008) and, in some cases, even when meat is analyzed at the aggregated level (see Gouldetal.2002;Golan, Perloff, and Shen2001;Sabates , Gould, and Villarreal 2001; Dong and Gould2000;Dong, Shonkwiler, and Capps 1998; and Heien, Jarvis, and Perali1989).

To perform the forecasts and simulation analysis, additional data is obtained from IMF, IFS Online Database; FAPRI (2008); FAPRI (2009); and Mexican Secretariat of Economy. Data on Mexican nominal GDP, Mexican GDP deflator, Mexican population, nominal exchange rate (pesos/dollar), and U.S. GDP deflator for the period 2006-2008 is obtained from IMF, IFS Online Database. Data on Mexican real GDP growth projection, Mexican population growth projection, Mexican-U.S. nominal exchange rate growth projection, U.S. GDP deflator growth projection, and Mexican GDP deflator growth projection for the year 2007 and the period 2008-2018 is obtained from FAPRI (2008) and FAPRI (2009) respectively. Mexican per household real meat expenditure growth projection and Mexican real exchange rate growth projection are computed using this data. The projection of real meat expenditures is obtained from the real GDP projection by using the proportion of income that is allocated to meat expenditures in year 2006, which is 0.36%.

The expenditure elasticities are combined with the Mexican per household real meat expenditure growth projection to forecast the Mexican per capita consumption by meat cut. Then, the per capita consumption by meat cut combined with the Mexican population projection allow to forecast the total Mexican consumption by meat cut. Similarly, the income and the Marshallian own-price elasticities are combined with the Mexican per household real meat expenditure growth projection and the real exchange rate growth projection to forecast total Mexican imports by meat cut.

[7] This study found statistical evidence, according to DuMouchel and Duncan's (1983) test, that suggests that the use of weights is necessary when working with ENIGH 2006. Eighteen DuMouchel and Duncan's (1983) tests were performed (one test at a time) by regressing meat-cut quantities on all the meat-cut prices, total meat expenditure, regional dummy variables, and urbanization level dummy variables, and computing the *F* statistic following “Method A” in DuMouchel and Duncan (1983, p. 539). At the 0.05 significance level, sixteen out of eighteen tests reject the null hypothesis of using the unweighted estimator and favor the use of weighted estimator.

[8] Average prices and quantities are computed incorporating the variables strata and weight (see SAS Institute Inc. 2004, pp.4313−4362).

Given that Mexican imports of beef and pork are not reported at the same level of disagregation that is reported for consumption, the import amounts in the year 2006 for the several table cuts of meats are estimated in several ways.

Table 1. Number of Non-Missing and Missing Observations and Average Prices

p_i	Number Non-Missing	Number Missing	Before p_i Imputed		After p_i Imputed	
			Mean (Pesos/Kg)	Std. Error of Mean	Mean (Pesos/Kg)	Std. Error of Mean
Beef						
p_1	6,348	10,561	61.3642	0.2572	60.8785	0.1059
p_2	2,938	13,971	55.6279	0.4059	56.2014	0.0780
p_3	2,795	14,114	52.0036	0.6439	51.4183	0.1199
p_4	734	16,175	36.8413	1.0864	35.8138	0.1046
Pork						
p_5	892	16,017	50.3311	0.6043	50.3466	0.0417
p_6	1,506	15,403	47.0965	0.5020	46.9521	0.0519
p_7	366	16,543	48.6391	0.9688	47.9718	0.0515
p_8	2,168	14,741	46.8656	0.5416	46.7112	0.0816
Processed Beef & Pork						
p_9	3,175	13,734	50.7869	0.9072	51.2935	0.1824
p_{10}	4,156	12,753	50.5261	0.4528	48.7871	0.1385
p_{11}	2,384	14,525	31.2680	0.5327	31.4529	0.0849
p_{12}	2,626	14,283	72.5129	1.1257	73.8783	0.2174
Chicken						
p_{13}	5,057	11,852	35.2406	0.2458	34.6859	0.0969
p_{14}	5,716	11,193	28.5982	0.2876	28.1278	0.0953
p_{15}	760	16,149	22.4321	0.8949	24.8824	0.0924
Processed Chicken						
p_{16}	2,593	14,316	46.7430	0.5581	46.0728	0.1000
Seafood						
p_{17}	3,970	12,939	48.7240	0.5964	47.9096	0.1596
p_{18}	713	16,196	81.5472	2.2547	87.1642	0.1806

Note: Average exchange rate in 2006 is US$1 = 10.90 Pesos (Banco de México).

p_i, $i = 1, \dots, 18$, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs andbreasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham andsimilar products, 17 = fish, 18 = shellfish.

Source:ENIGH (2006) Database, computed by authors.

From the total volume of Mexican beef imports in 2006, approximately 22.88% was edible beef offal and 1.13% was processed beef (Mexican Secretariat of Economy).[9]The import shares of beefsteak, ground beef, and other beef are estimated using the remaining

[9] The 2006 import shares of edible beef offal and processed beef were computed from chapter 2 (meat and edible meat offal) of the Harmonized System. At the 8-digit level of disagregation, edible beef offal includes commodities 02061001, 02062101, 02062201, and 0206299. Processed beef includes commodity 02102001 and half the import amount of commodity 02109999.

import share of 75.99% and the ENIGH 2006 consumption structure (i.e., the structure that is obtained from beefsteak, ground beef, and other beef from column six of table 2).

Table 2. Per Capita Consumption of Meat Cuts Per Week

q_i	Number of Non-Zero Obs.	Number of Zero Obs.	Excluding Zero Obs. Mean (Kg/Capita)	Excluding Zero Obs. Std. Error of Mean	Including Zero Obs. Mean (Kg/Capita)	Including Zero Obs. Std. Error of Mean
Beef						
q_1	6,348	10,561	0.2689	0.0040	0.1078	0.0022
q_2	2,938	13,971	0.2089	0.0052	0.0369	0.0012
q_3	2,795	14,114	0.3170	0.0093	0.0562	0.0020
q_4	734	16,175	0.3249	0.0168	0.0151	0.0011
Pork						
q_5	892	16,017	0.2231	0.0095	0.0109	0.0007
q_6	1,506	15,403	0.2699	0.0083	0.0205	0.0519
q_7	366	16,543	0.1755	0.0090	0.0038	0.0003
q_8	2,168	14,741	0.2839	0.0240	0.0388	0.0035
Processed Beef & Pork						
q_9	3,175	13,734	0.1265	0.0038	0.0239	0.0009
q_{10}	4,156	12,753	0.1340	0.0031	0.0352	0.0017
q_{11}	2,384	14,525	0.1787	0.0050	0.0264	0.0010
q_{12}	2,626	14,283	0.1363	0.0048	0.0221	0.0010
Chicken						
q_{13}	5,057	11,852	0.4100	0.0065	0.1458	0.0032
q_{14}	5,716	11,193	0.4480	0.0073	0.1403	0.0032
q_{15}	760	16,149	0.4719	0.0563	0.0251	0.0035
Processed Chicken						
q_{16}	2,593	14,316	0.1969	0.0056	0.0293	0.0011
Seafood						
q_{17}	3,970	12,939	0.2762	0.0075	0.0676	0.0023
q_{18}	713	16,196	0.2783	0.0169	0.0113	0.0009

Note: q_i, $i = 1, \ldots, 18$, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs andbreasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham andsimilar products, 17 = fish, 18 = shellfish.
Source: ENIGH (2006) Database, computed by authors.

That is, approximately 40.78%, 21.25%, and 13.96% of the total volume of Mexican bovine meat imports were beefsteak, other beef, and ground beef respectively. Similarly, from the total volume of Mexican pork imports in 2006, approximately 9.15% was processed pork (Mexican Secretariat of Economy).[10]The import shares of pork steak, pork leg and shoulder, ground pork, and other pork are estimated using the remaining import share of 90.85% and

[10] The 2006 import share of processed pork was also computed from chapter 2 of the Harmonized System. At the 8-digit level of disagregation, processed pork includes commodities 02090099, 02101101, 02101201, and 02101999, and half of the import amount of commodity 02109999.

the ENIGH 2006 consumption structure (i.e., the structure that is obtained from pork steak, pork leg and shoulder, ground pork, and other pork from column six of table 2). That is, approximately, 71.73%, 13.88%, 3.89%, and 1.35% of the total volume of Mexican swine meat imports were pork leg and shoulder, other pork, pork steak, and ground pork respectively. Likewise, from the total volume of Mexican chicken imports in 2006, approximately 81.24%, 10.73%, 8.00%, and 0.01% were chicken legs and thighs and breasts, chicken offal, whole chicken, and chicken ham and similar products respectively (Mexican Secretariat of Economy).[11]

RESULTS AND PROJECTIONS

Table 3 reports the estimates of the Marshallian own- and cross-price elasticities[12]. For all Marshallian own-price elasticities the expected negative signs are obtained while for the cross-price elasticities the results are mixed: some are positive, implying cases of substitutes meat cuts; and others are negative, implying cases of complement meat cuts. For example, cases of (gross) substitutes include beefsteak and pork steak, and beef offal and chicken offal and pork steak and pork leg and shoulder.

The own-price elasticities show that the demands are elastic for all meat cuts, except for fish, and ham, bacon and similar products. This is consistent with most demand studies at the differentiated level (e.g., Chidmi and Lopez2007;and Nevo2001).[13]

The own-price elasticities range from -15.9428 for ground pork to -0.7832 for ham, bacon, and similar products from beef and pork. A direct comparison between our results and the results from previous meat demand studies is not insightful given the difference in the level of aggregation.

Table 4 presents the expenditure elasticities. All expenditure elasticities have the expected positive sign and are statistically different from zero at the 0.05 significance level, except for ground pork.

This implies that all the meat cuts are normal goods and that consumption on all meat cuts is expected to increase as the economy grows. The expenditure elasticities ranges from 0.1846 for ground pork to 0.9733 for beefsteak. Since all the expenditure elasticities are less than one, none of the meat cuts is considered a “luxury” commodity. The results also show that most pork-cut elasticities have lower values (therefore more necessary goods) than most beef-cut elasticities, and chicken-cut elasticities, except for processed beef and pork (i.e., chorizo, ham and bacon and similar products, beef and pork sausages, and other processed beef and pork).

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[11] Similarly, the 2006 import share of chicken legs and thighs and breasts, whole chicken, chicken offal, and chicken ham and similar products were computed from chapter 2 of the Harmonized System. At the 8-digit level of disaggregation, chicken legs, thighs, and breasts include commodities 02071301, 02071401, 02071303, and 02071404. Whole chicken includes commodities 02071101 and 02071201. Chicken offal includes commodities 02071302, 02071399, 02071402, 02071403, and 0271499. Chicken ham and similar products include commodities 02090001 and 02109903.

[12] Maximum-likelihood parameter estimates from univariateprobit regressions (step 1), SUR parameter estimates from the system of equation (step 2), and Hicksian price elasticities are available upon request.

[13] The demand for a narrowly defined good is more elastic than the demand for a broadly defined good. In this study, fish, and ham, bacon and similar products are broadly defined.

Table 3. Marshallian Price Elasticities
Table entries estimate e_{ij}.

i\j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	-1.0270*	0.1874†	-0.4383*	-0.1690	0.1565	-0.3042†	-0.1590	0.0375	0.0174	-0.0030	-0.0186	-0.0346	-0.2778*	-0.0361	0.0325	-0.1666†	-0.0394	-0.6354*
2	0.3941*	-3.4594*	-0.1164	-0.1068	0.4419	0.3923	0.3808	0.1548	-0.0236	0.0619	-0.0916	-0.0081	0.0032	0.2245	0.1064‡	-0.1294	-0.0950	-0.9724*
3	-1.2609*	0.2100	-1.7451*	0.2404	1.2346*	-0.5032	-3.3987*	-1.0235*	0.1885	0.0609	0.2369	-0.1490	-0.3109*	0.0158	0.2704	0.1163	-0.1758	-0.6919*
4	-1.8100*	0.4889	-0.3440	-4.8186*	-1.3840	0.8117†	-1.5508	-0.2194	0.6108	-0.2380	0.5040	-0.7262‡	-0.6557‡	-0.4232†	0.4998	-0.2088	-1.3958*	1.1782
5	0.7866	-0.7295†	0.0720	-0.2287	-4.4711*	-1.1063	-1.6662†	0.7246†	-0.4432†	-0.5834‡	0.0896	-0.1335	-0.1423	-0.5410†	0.2138†	0.8314*	0.0147	-0.9145†
6	-1.2086*	-0.5236	0.0135	0.4876†	-0.7959	-4.8375†	0.9168	0.3153	-0.1748	-0.3171	0.0492	0.5835*	0.1087	-0.4584†	0.0094	0.1924	0.1516	0.3673
7	-2.4904*	-0.5660	0.2482†	0.1254	-1.9010	-0.8229	-15.9428‡	-0.2945	0.1764	-0.0677	0.6991‡	-1.4896*	-0.2333	-0.5569†	-0.3212	-0.6395	-0.4851†	-0.6696
8	-0.1314	0.4929	0.3194	0.3868†	1.4251‡	1.6971*	-1.9708†	-8.3019*	0.6219	0.0730	0.5472	-0.4080	-0.2200	-0.3565†	0.0529	-0.8650†	-0.2177	0.4907
9	0.1705	-0.0911	0.1114	-0.0318	0.9794‡	-0.3901	0.0174	-0.1277	-1.2275*	-0.6150	-0.0932	-0.3774*	-0.1623	-0.2235†	-0.3070*	-0.3966†	-0.0510	0.0536
10	0.2400†	-0.7629*	0.4232*	-0.2591	0.1586	0.1704	-1.3375*	0.1069	0.0478†	-0.7832*	0.2719‡	0.2156	0.0995	0.1305‡	-0.4764*	0.2149	0.0845‡	0.4884
11	-0.3879*	-0.1636	0.1905*	-0.5674‡	1.0437*	-0.8304‡	0.4634†	0.6703*	0.0787‡	-0.0091	-1.8406†	-0.1287‡	-0.0014	-0.1101	-0.2771	0.3034	0.2344*	0.6494
12	0.1538	-0.7593†	0.0713	-1.2194*	-2.2317*	0.0021	0.5628	-0.3655	0.1009	-0.6053*	0.0806	-3.1156*	0.5946*	-0.0236	-0.6132*	0.2790‡	0.0330	0.3075
13	-0.2773‡	0.0030	0.0300	-0.4099*	0.2920	0.3180†	0.6752*	-0.0566	0.0603	0.1820*	-0.0051	0.1125	-1.2841*	-0.1555*	-0.0368	0.1865‡	0.0551†	0.0615
14	0.3895†	-0.3419†	-0.2401	-0.1481‡	-0.0380	0.0698	-0.2241	0.0332	-0.0866	-0.2281†	-0.1014	0.0320	0.0290	-1.2640*	0.1768†	-0.0120	-0.7013*	-0.0068
15	0.0033	0.2217	0.0484	0.3276	0.7168	0.4577	-1.7283	0.1402	-2.0678	-2.6776	1.0031	0.2440	-0.1783	-0.2035	-9.1730*	1.1161†	-0.4770	-0.0833
16	-0.0592	0.2251	0.0547	0.1362	2.1079*	0.2196	-1.7323*	0.6956†	0.0533	0.1333	0.2558†	0.0448	0.2076†	0.0365	0.1239	-1.2713*	0.0404	0.1742
17	-0.0347	-0.1137	0.0638	-0.1373	0.9090*	-0.6018†	-1.6105‡	0.1549	-0.0718	0.2375†	0.1125	0.0456	-0.0525	0.1371	0.2298‡	0.1382	-0.9825*	0.6658*
18	-1.0742‡	0.5885†	-0.6597*	0.1389	0.8832	0.3021	0.2106	-0.5493	0.0255	0.2046	0.4451†	0.0774	-0.1591	-0.0278	0.1831	1.1353‡	-0.0001	-7.5997*

Note: $i, j = 1, \ldots, 18$, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs andbreasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham andsimilar products, 17 = fish, 18 = shellfish. Number of bootstrap resamples = 1,000. Bootstrap significance levels of 0.05, 0.10 and 0.20 are indicated by asterisks (*), double daggers (‡) and daggers (†) respectively.

Table 4. Expenditure Elasticities

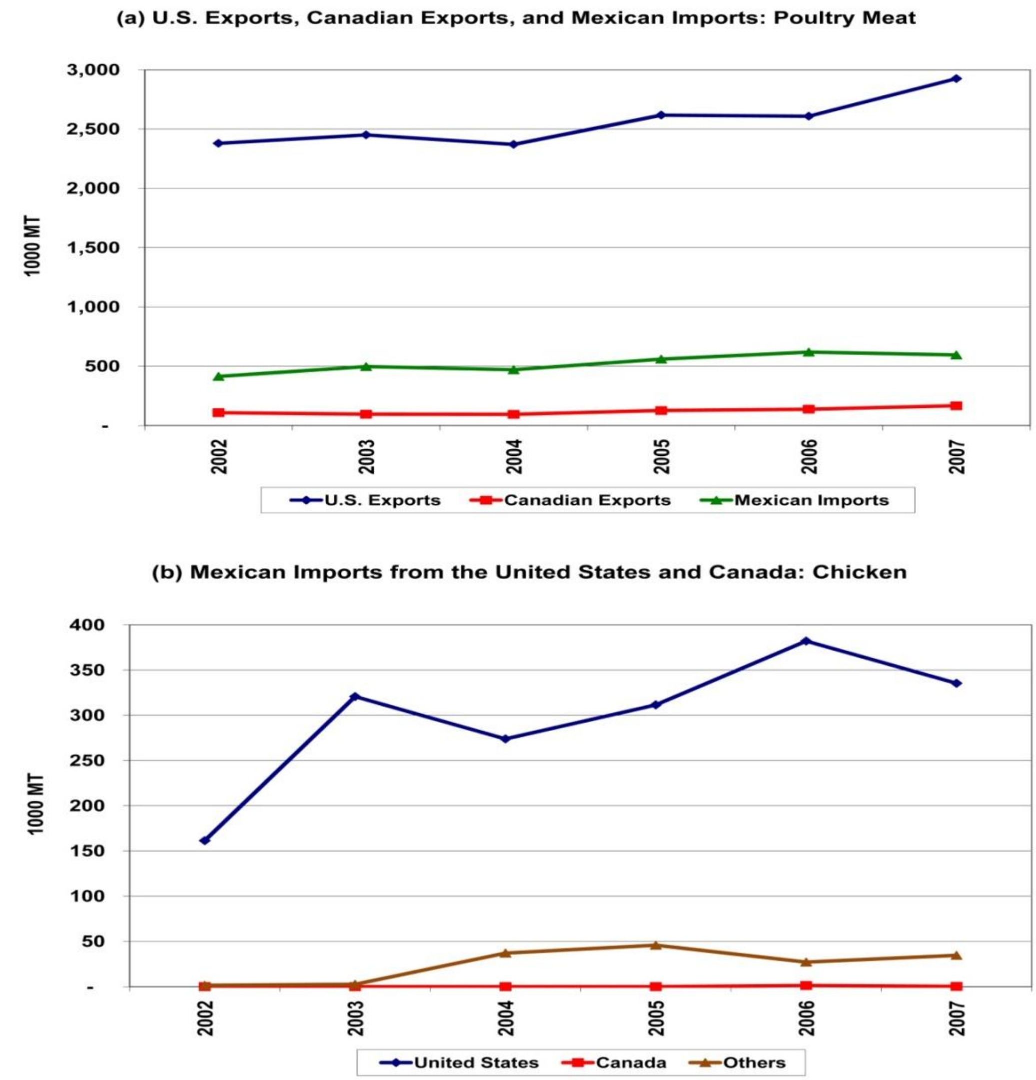
	i	$\hat{e}_i$
1	Beefsteak	0.9733*
2	Ground Beef	0.5228*
3	Other Beef	0.7260*
4	Beef Offal	0.6413*
5	Pork Steak	0.3904*
6	Pork Leg & Shoulder	0.5141*
7	Ground Pork	0.1846
8	Other Pork	0.5776*
9	Chorizo	0.6190*
10	Ham, Bacon & Similar Products	0.4547*
11	Beef & Pork Sausages	0.2728*
12	Other Processed Beef & Pork	0.3570*
13	Chicken Legs, Thighs & Breasts	0.6142*
14	Whole Chicken	0.6761*
15	Chicken Offal	0.6112*
16	Chicken Ham & Similar Products	0.3354*
17	Fish	0.6970*
18	Shellfish	0.4361*

Note: Number of bootstrap resamples = 1,000. Bootstrap significance levels of 0.05, 0.10 and 0.20 are indicated by asterisks (*), double daggers (‡) and daggers (†) respectively.

Figures 4, 5 and 6 report the current and forecasted Mexican consumption of beef, pork, and chicken. The consumptions of beef and veal, pork, and broiler by FAPRI, which are illustrated in panels (a), are the projections reported in FAPRI (2009,p. 342) and FAPRI (2009). On the other hand, the consumptions of beef, pork and chicken (q_{beef}, q_{pork}, and $q_{chicken}$) in panels (a), are the projections obtained in this study (using FAPRI 2009 baseline assumptions). The projections q_{beef}, q_{pork}, and $q_{chicken}$ are obtained from the sum of the corresponding meat cuts. That is, $q_{beef} = \sum_{i=1}^{4} q_i + q_{processed\ beef}$, $q_{pork} = \sum_{i=5}^{8} q_i + q_{processed\ pork}$, $q_{chicken} = \sum_{i=13}^{16} q_i$, $q_{processed\ beef} = \sum_{i=10}^{12} 0.5\ q_i$, and$q_{processed\ pork} = q_9 + \sum_{i=10}^{12} 0.5\ q_i$. The indexes reported in the panels (b) are computed by dividing all values in a series by its value in year 2006. Consequently, these indexes show the growth rate from year 2006 to any year.

Panel (a) in figure 4 indicates that total Mexican beef consumption is expected to be greater than the values predicted by FAPRI (2009,p.342). In addition, beefsteak is expected to continue to be the most consumed beef cut, followed by other beef, processed beef, ground beef and beef offal. Panel (b) shows that beefsteak consumption is expected to be the fastest growing beef cut (2006-2018 growth rate of 57%), while processed beef consumption is expected to be the slowest growing beef cut (2006-2018 growth rate of 28%), and ground beef, other beef and beef offal consumption are expected to have growth rates of 35%, 44% and 40% respectively.

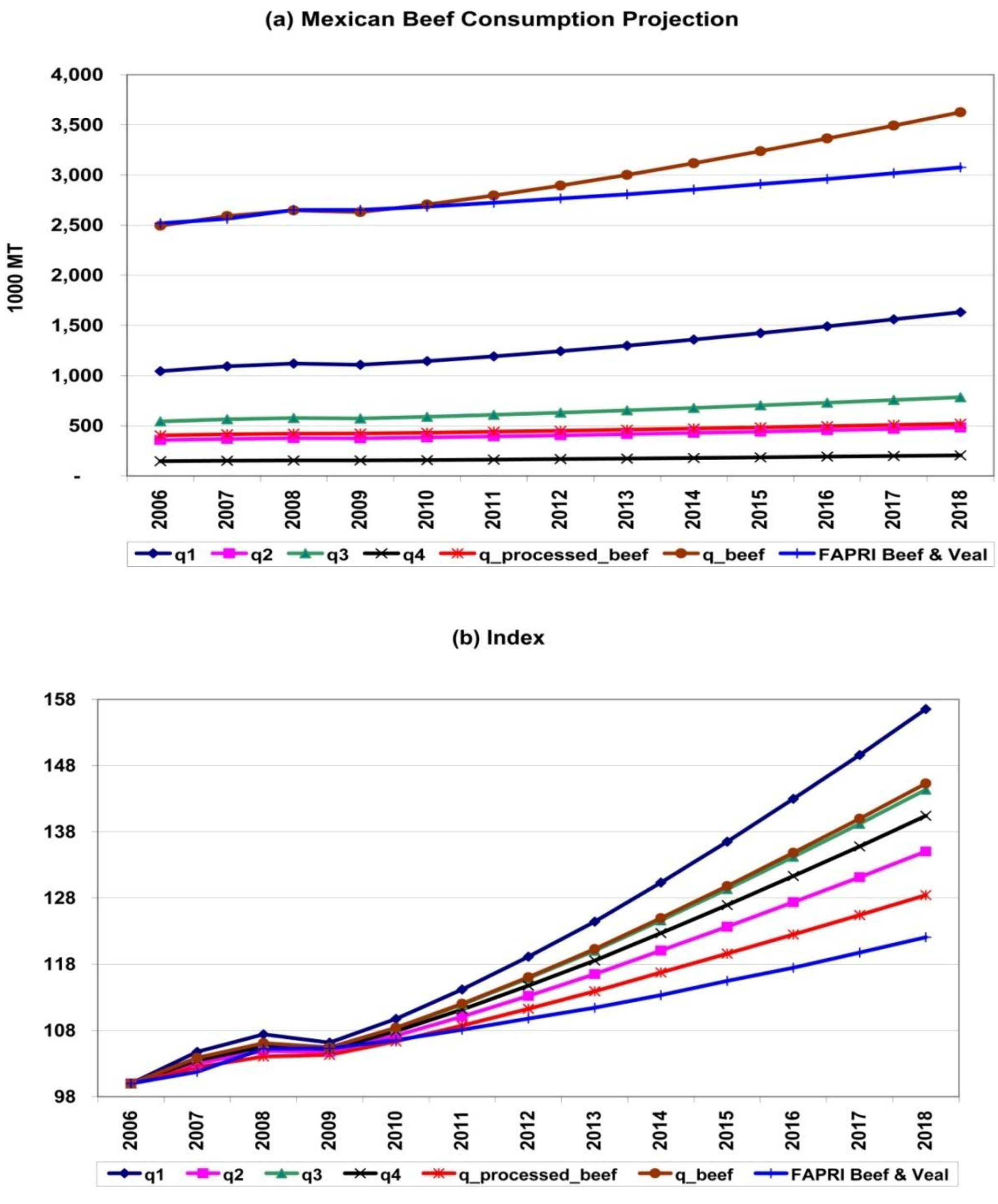
This indicates that Mexican beef consumption seems to be following the U.S. preferences for beef cuts, where the most expensive meat is consumed the most (i.e., beefsteak) and the cheapest meat is consumed the least (e.g., beef offal and processed beef).



Note: Series in Panel (b) were computed from chapter 2 (meat and edible meat offal) of the Harmonized System.Chicken is the sum of whole chicken, boneless chicken, chicken legs and thighs, and other chicken cuts and offal. At the 8-digit level of disaggregation, whole chicken includes commodities 02071101 and 02071201. Boneless chicken includes commodities 02071301 and 02071401. Chicken legs and thighs include commodities 02071303 and 02071404. Other chicken cuts and offal include commodities 02071302, 02071399, 02071402, 02071403 and 02071499. All years are calendar years (January to December) except for 2002, which was reported from April to December.

Source:Panel (a) from USDA-ERS-PSD Online Database. Panel (b) from Mexican Secretariat of Economy, SIAVI Database. Charts computed by authors.

Figure 3. Chicken trade.

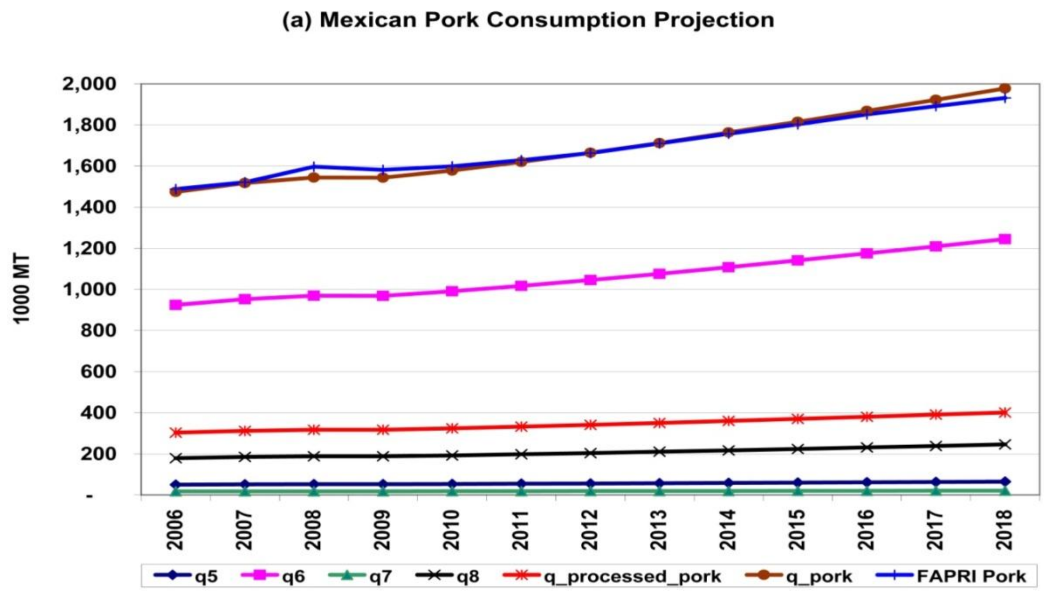


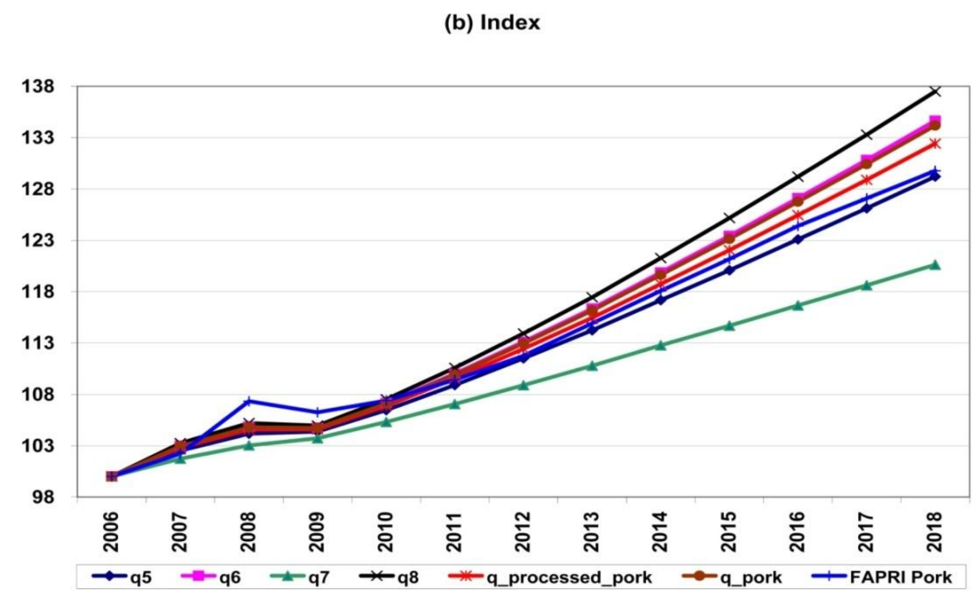
Note: FAPRI beef and veal consumption is the projection reported in FAPRI (2009, p. 342) and FAPRI (2009).

q_i, $i = 1, \ldots, 4$, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal.

Figure 4. Mexican beef consumption projection.

In the case of Mexican pork consumption (figure 5), pork leg and shoulder is expected to continue to be the most consumed pork cut (panel (a)), but the second fastest growing pork cut (panel (b)). In addition, pork leg and shoulder is expected to grow at about the same rate as the total pork consumption.



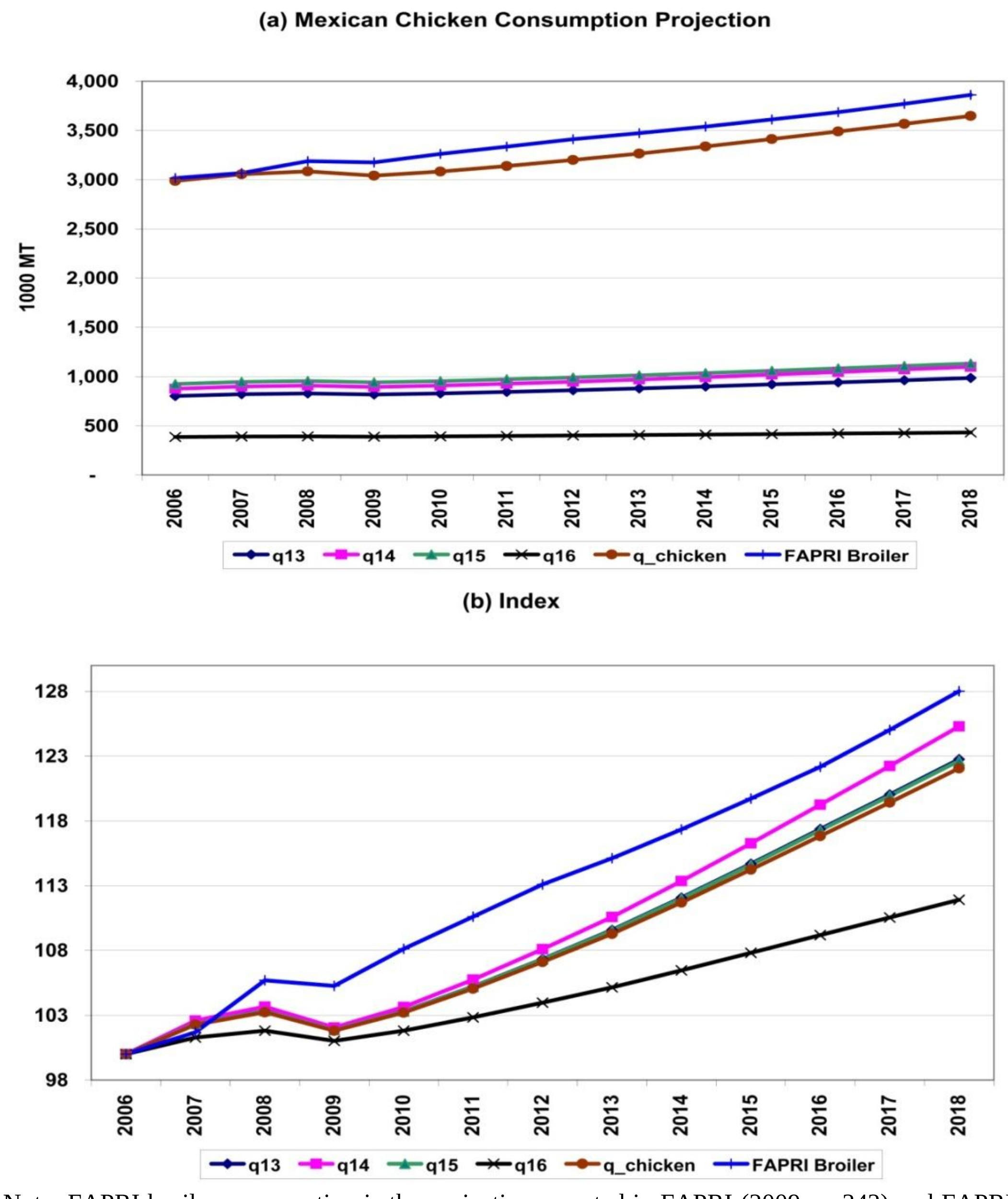


Note: FAPRI pork consumption is the projection reported in FAPRI (2009, p.342) and FAPRI (2009).

q_i, $i = 5, \ldots, 8$, where 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork.

Figure 5. Mexican pork consumption projection.

The other four pork cuts considered, whose consumption is far much lower than the consumption of pork leg and shoulder (panel (a)), are expected to grow at different growth rates (panel (b)). The most rapidly growing is expected to be other pork (2006-2018 growth rate of 37%) and the slowest growing is expected to be ground pork (2006-2018 growth rate of 21%). At the aggregate level, our projection for total Mexican pork consumption is very close to the values predicted by FAPRI (2009, p. 32).

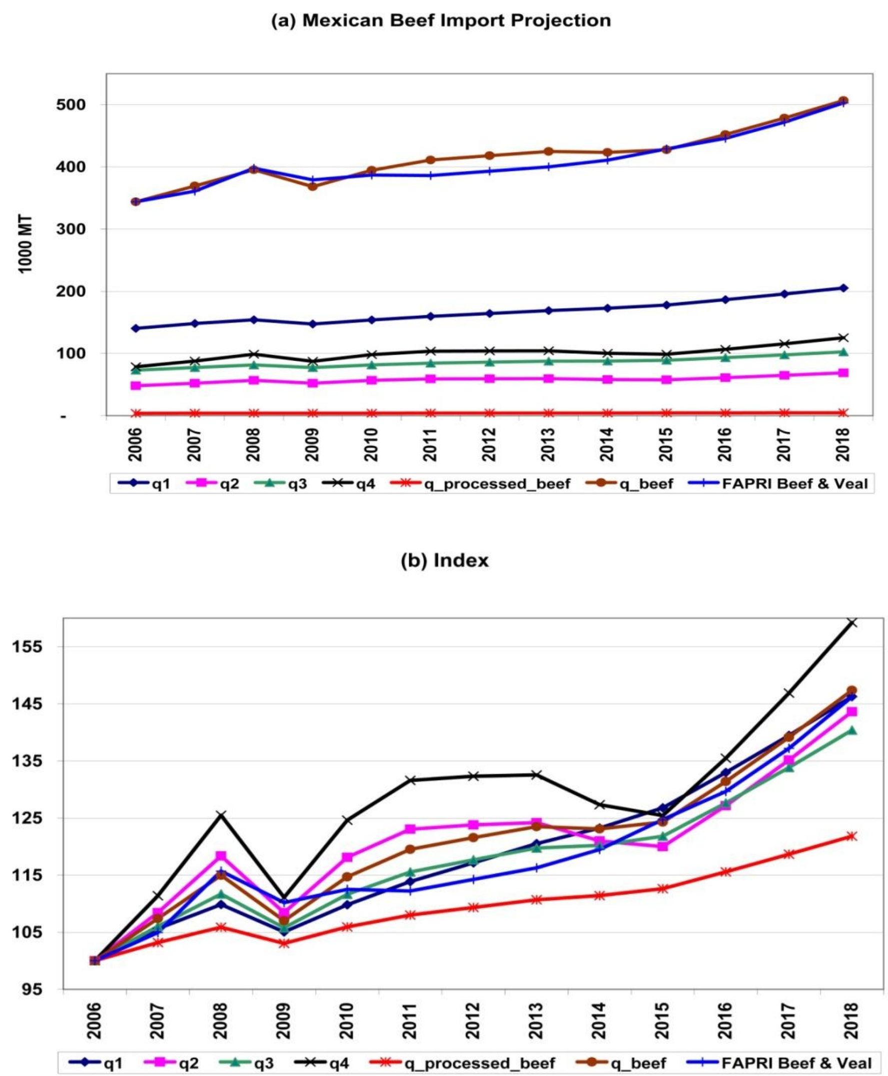


Note: FAPRI broiler consumption is the projection reported in FAPRI (2009, p. 342) and FAPRI (2009).

q_i, $i = 13, \ldots, 16$,, where 13 = chicken legs, thighs and breasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham and similar products.

Figure 6. Mxican chicken consumption projection.

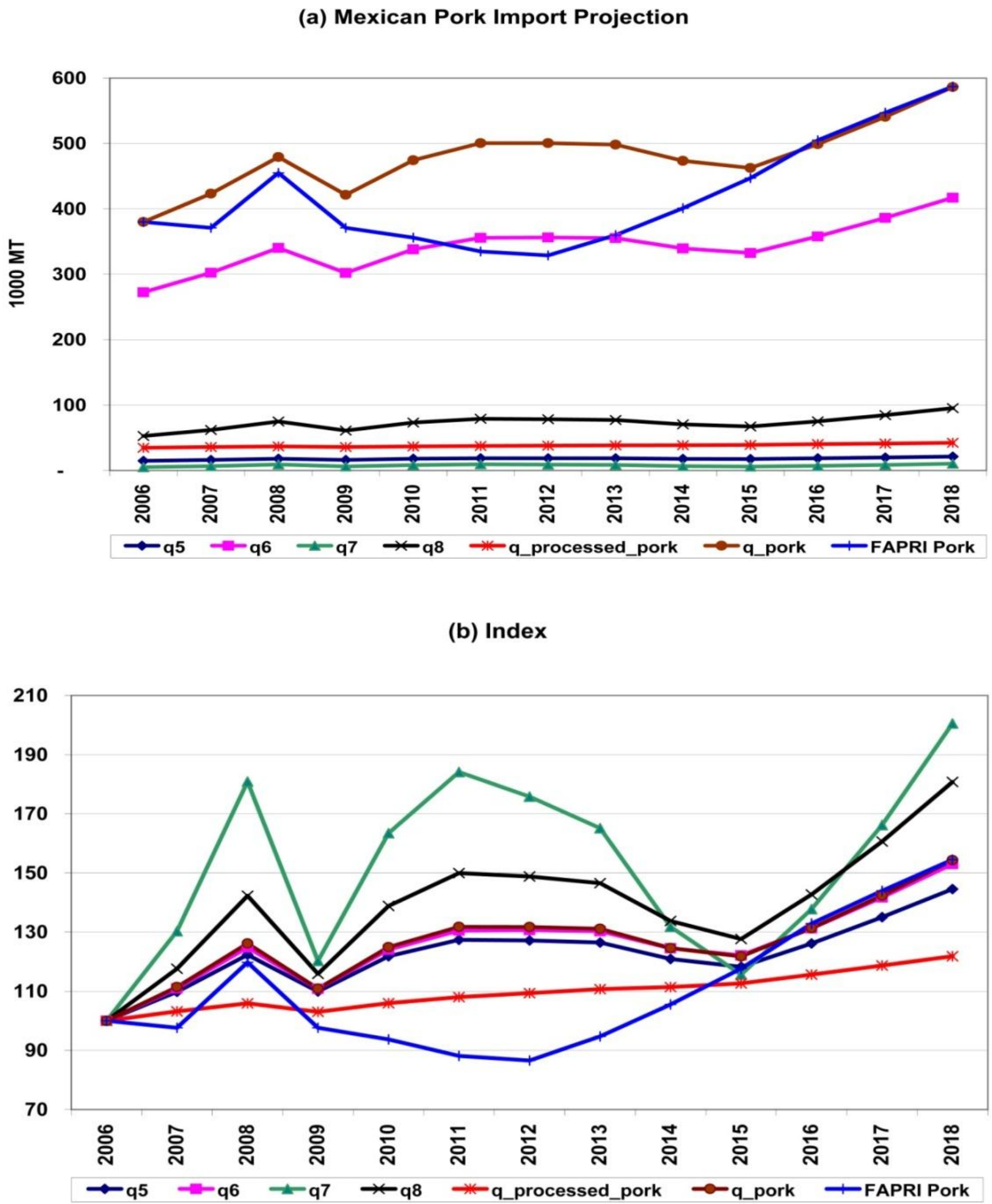
In the case of chicken (figure 6), the consumption of chicken offal, whole chicken, and chicken legs, thighs and breasts are expected to be about the same (panel (a)) and to grow at about the same rate, 2006-2018 growth rate of 24% (panel (b)). Hence, unlike the case of beef consumption, Mexican chicken consumption does not seem to be following the U.S. preferences for chicken cuts, where there is high preference for chicken breasts and low preference for chicken offal. Contrary to the other chicken cuts, chicken ham and similar products is consumed at the lowest level (panel (a)) and is expected to grow at the lowest rate (panel (b)). At the aggregate level, our results indicate that chicken consumption is expected to be lower than what is predicted by FAPRI (2009, p.342).



Note: FAPRI beef and veal imports is the projection reported in FAPRI (2009, p. 325) and FAPRI (2009).

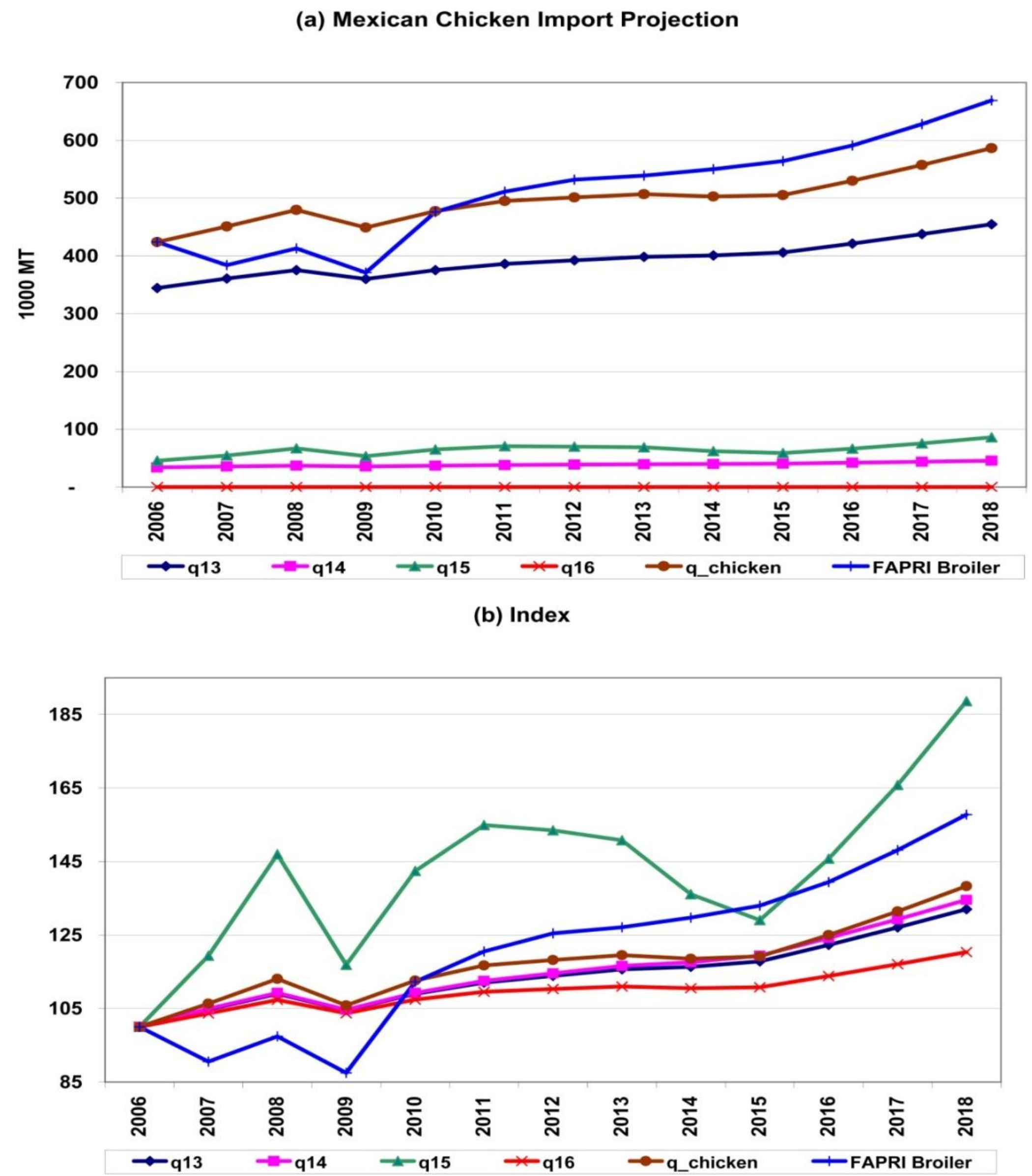
q_i, $i = 1, \dots, 4$, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal.

Figure 7. Mexican beef import projection.



Note: FAPRI pork imports is the projection reported in FAPRI (2009, p. 327) and FAPRI (2009). q_i, $i = 5, \ldots, 8$, where 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork.

Figure 8. Mexican pork import projection.



Note: FAPRI broiler imports is the projection reported in FAPRI (2009 p. 329) and FAPRI (2009). q_i, $i = 13, \ldots, 16$, where 13 = chicken legs, thighs and breasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham and similar products.

Figure 9. Mexican chicken import projection.

Figures 7, 8 and 9 report the current and forecasted imports of Mexican beef, pork, and chicken. The imports of beef and veal, pork and broiler by FAPRI in panels (a) are the projections reported in FAPRI (2009pp. 325, 327, and 329) and FAPRI (2009); while q_{beef}, q_{pork}, and $q_{chicken}$ are the projections obtained in this study using FAPRI (2009) baseline assumptions. The projections q_{beef}, q_{pork}, and $q_{chicken}$ are obtained from the sum of the corresponding meat-cut imports. The indexes reported in the panels (b) show growth rates from year 2006 to any year. The Mexican beef imports projections presented in this study are very close to FAPRI (2009,p.325) projections. The results in panel (a) in figure 7 show that our beef import projections are expected to be about 5% greater from 2010 to 2014, and about 1% greater from 2015 to 2018. On the contrary, the Mexican pork import projections in this study are widely greater than FAPRI (2009,p. 327) projections from 2010 to 2014 (about 38%), but they are about the same from 2015 to 2018 (less than 1% greater), panel (a) in figure 8. Finally, the Mexican chicken imports in this study are lower than FAPRI (2009p. 329) projections from 2011-2018 (about 8%), panel (a) in figure 9. However, this study has the advantage that it reports import projections and growth rates at the table cut level of dissagregation. In the case of Mexican chicken imports (figure 9), chicken legs, thighs and breasts is the most imported chicken cut (panel (a)), but the fastest growing chicken cut is chicken offal (panel (b)). The 2006-2018 import growth rate of chicken offal is about 89%, while for whole chicken, chicken legs and thighs and breasts, and chicken ham and similar products, the import growth rates are 35%, 32%, and 20% respectively. In addition, the growth rate of chicken offal is volatile while the growth rates of whole chicken, chicken legs and thighs and breasts, and chicken ham and similar products are smoother.

CONCLUSION AND DISCUSSION

Previous Mexican meat demand studies have all aggregated Mexican meat into broad categories or analyzed meat as one product within a more general demand system (i.e., including cereals, meat, dairy, fats, fruit, vegetables, etc.). This study presents an analysis at the table cut level of disaggregation. Our findings indicate that Mexican consumption of table cuts of meats grow at different rates within each meat category (except for the chicken category where only chicken ham and similar products have a lower growth rate). Similarly, our results indicate that Mexican imports of table cuts of meats grow at different rates.

For example, Mexican consumption of beefsteak is the fastest growing within the beef category, but consumption of pork steak is not the fastest growing within the pork category. On the contrary, Mexican consumption of ground beef and ground pork are among the slowest growing within their corresponding meat category. Similarly, Mexican consumption of processed beef, and chicken ham and similar products are the slowest growing within their corresponding meat category. Furthermore, our results indicate that Mexico seems to be following the U.S. preferences for beef cuts, but not for chicken cuts. In the case of Mexican imports, chicken legs, thighs and breasts are expected to continue to be the most imported chicken cuts, but the fastest growing chicken cut is chicken offal.

The results presented in this study are very insightful because they are discussed and reported at the table cut level. In addition, projections may be more precise if meat cuts, instead of aggregated categories, are considered. However, much effort is needed to keep records of imports and exports at the table cut level. The current categories of the harmonized system, especially in the case of beef and pork, does not allow to analyze meat imports and exports at the same level of disaggregation that it is done with meat consumption. Consequently, this study combines import data from Mexican Secretariat of Economy with consumption data from ENIGH 2006 to estimate the import structure of some of the beef and pork cuts considered.

Large U.S. and Canadian exporting companies know with precision how much of each meat cut they export to Mexico. Hence, they can use the elasticity estimates reported in this study to forecast future exports to Mexico. This study may also assist them in conducting long-term investment decisions in the meat industry and/or identifying trends in specific table cuts of meats. However, it is essential to understand that this analysis is based on elasticity estimates and FAPRI baseline assumptions. A sensitivity analysis based on FAPRI baseline assumptions could be performed to evaluate how Mexican consumption and imports of table cuts of meats may change.

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FINANCIAL DEVELOPMENT AND INTERNATIONAL TRADE: AN EMPIRICAL ANALYSIS

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ABSTRACT

We empirically investigate the effects of financial development on bilateral trade flows for both agricultural and manufactured products. Overall, we found that financial development has positive impacts on agricultural and manufacturing exports; but the impacts are not substantially different between the two sectors. However, our regional analysis suggests that the impacts of financial development on exports differ significantly between sectors and across regions. In most cases, the impacts of financial development on exports are higher in developing countries (Asia, Latin America, MENA and SSA) than in developed countries and they are higher in the higher economies of scale sector as represented by manufacturing sector than in the less economies of scale sector as represented by agricultural sector.

Keywords: agricultural sector, comparative advantage, financial development, international trade, manufacturing sector.

JEL Codes: F10, F30, Q17

INTRODUCTION

Recent literature in international trade suggests that financial development can be a potential source of comparative advantage and thus trade patterns. This notion builds on the analysis of Kletzer and Bardhan (1987) and Baldwin (1989). Using an augmented Heckscher–Ohlin model, Kletzer and Bardhan (1987) show that a well developed financial sector can theoretically lead to a comparative advantage in industries that rely more on external financing. Baldwin (1989) developed one of the first models in which financial markets are a source of comparative advantage. He argues that financial development may affect the output

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decision of firms and thus trade patterns. The two papers generally suggest that countries that are well developed financially should experience greater volumes of international trade.

The channels through which financial development can translate into a comparative advantage and trade patterns can vary, with the most prominent arguments is based on the liquidity constraints that most firms face. From this perspective, when a domestic financial institution is weak and inefficient, firms in export-oriented sectors are burdened by liquidity constraints that prevent a subset of productive firms from entering the foreign market (Chaney, 2005). Until the 1980s, this situation obviously occurred in most countries in which financial sector was subject to state interventions (Abiad et al., 2010) including government owned and controlled bank, imposing entry restrictions and barriers to foreign capital flows, constraining credit allocations, among others. On the other hand, firms in financially developed countries face less restrictive credit constraints and therefore can increase investment in response to a lowering of variable export costs and all firms with productivity above a certain cut-off level become exporters (Melitz, 2003). A model with credit-constrained generally predicts that financially developed countries are more likely to export bilaterally and ship greater volumes (Manova, 2008).

The purpose of this paper is to empirically investigate the impacts of financial development on trade flows. What we mean by financial development is the extent to which financial sector is liberalized, usually through deregulation. This issue merits consideration given that most countries in both developing and developed countries have undergone extensive financial liberalization, particularly in the early 1990s. We are interested in answering the following questions. What has been the effect of financial development on exports and are there differences between sectors with different economies of scale? The later question is in line with Beck’s (2002) suggestion that financial development and trade relationships may be subject to economies of scale. Another important question is whether the impacts of financial developments on exports differ across country groups or regions. Given that the level of financial development varies vastly across country groups, we suspect that such variation may help explaining export behavior.

Our financial development indicator is measured using a financial reform index developed by Abiad *et al.* (2010). The index is constructed based on different dimension of financial sector policy such as interest controls, entry restrictions, and state ownership. Therefore the index also indicates financial liberalization. The index values range from 0 to 1 with higher value indicates higher level of financial development. An index value of zero means that the financial sector is fully repressed and an index value of one indicates fully developed.

The methodology used for estimation the impact of financial development on trade is to specify trade equations in the widely used form of the gravity model where the financial development variable is augmented in the gravity equation. To account for possible differential effects of country groups or regions, we include interaction terms between financial development variables and dummy variables representing regions. Two different sectors, agriculture and manufacturing, are analyzed to represent two different economies of scale where manufacturing is considered to have higher economies of scale than is agricultural sector. The model is estimated using fixed effects vector decomposition (FEVD). This method is deemed appropriate given that the gravity equation consists of time invariant variables and the FEVD can accommodate such variables.

RELATED LITERATURE REVIEW ON TRADE AND FINANCIAL DEVELOPMENT

A number of theoretical papers related to finance-trade link have been proposed with the earliest versions are those by Kletzer and Bardhan (1987) and Baldwin (1989). Using the Heckscher-Ohlin framework, Kletzer and Bardhan compared two international trade models with the same factor endowments but one sector in one of the models depends also on external finance for working capital. They show that the country with less credit market restrictions specializes in the sector that uses external finance and the country with the higher level of credit market restrictions specialize in the sector that does not require working capital or external finance. Their analysis concluded that a well developed financial sector can theoretically lead to a comparative advantage in industries that rely more on external financing and can explain the variance of the trade structure across countries.

On the other hand, the work of Baldwin is based on the risk-diversification function of a financial market consisting of two countries, two sectors, and one factor where the demand for one of the sectors is subject to demand shocks and the other is not. He posits that economies with better developed financial markets are better able to diversify risk because they have better diversification possibilities. Consequently, they specialize in producing the risky good with relatively lower risk premiums.

Based on the conclusions of Kletzer and Bardhan (1987) and Baldwin (1989), Beck (2002) investigated and explored the possible relation between financial development and international trade by building both a theoretical model and an empirical model to test his hypothesis. The theoretical model with two sectors shows that the sector with high scale economies profits more from a higher level of financial development. Therefore, countries endowed with a well developed financial system tend to specialize in sectors with high scale economies because of comparative advantage. The empirical model that uses both cross-country and panel estimations in a sample of 65 countries gives support to the prediction of the theoretical model. In his second study, Beck (2003) verified successfully the possible link between financial development and trade structure. That is, his empirical results provide robust evidence that countries with a higher level of financial development have higher export shares and trade balances in industries that rely more on external finance. These two studies firmly show that an increase in the level of financial development has a positive impact on the value of exports, especially if industries report a higher level of external financial dependence.

Further empirical studies on the finance-trade link have emerged in both firm-level and country or sectoral level. Muuls (2008) and Berman and Hericourt (2008) are among those who focus on firm-level data. Using a dataset on export transactions at the firm level for the Belgian manufacturing sector, Muul analyzes the interaction between credit constraints and exporting behavior. He found that firms are more likely to be exporting if they enjoy higher productivity levels and lower credit constraints. He concludes that credit constraints really do matter for export patterns. Berman and Hericourt show that the financial factor affects both the firms' export decisions and the amount exported by firms. Using a large cross-country firm level database in developing and emerging economies, they found that financial constraints create a disconnection between a firm's productivity and its export status. According to their results, an increase in a country's financial development increases the number of exporters and affects the exporters' selection process through dampening such a disconnection. These two studies agree that financial development does really matter for export patterns and economies with a higher level of financial development should have greater comparative advantage.

Examples of empirical work that study the sectoral level are given by Hur *et al*. (2006) and Manova (2008). Hur *et al*. investigated the impact of a country's financial development and a firm's asset structure on the trade flow of different industries. Using data for 27 industries in 42 countries they found that economies with higher levels of financial development have higher export shares and trade balance in industries with more intangible assets. Manova (2008) developed a model with credit-constrained heterogeneous firms, countries at different levels of financial development, and sectors of varying financial vulnerability. She shows that financially developed countries are more likely to export bilaterally and ship greater volumes when they become exporters. She empirically found robust, systematic variations in export participation, volumes, product variety, product turnover, and trade partners across countries at different levels of financial development and across sectors at different levels of financial vulnerability.

EMPIRICAL SPECIFICATION

Our analysis is based on the gravity model of panel data because of at least 2 reasons. First, the gravity model has been widely used to describe bilateral trade patterns and has given satisfactory performance in representing trade flows (Deardorff, 2004; Disdier and Head, 2008) and has strong theoretical foundations as provided in papers such as Anderson (1979) and Anderson and van Wincoop (2003). Second, unlike the regular cross-section model, gravity model with panel data provides an attractive way of dealing with unobserved heterogeneity as well as functional specifications (Baldwin, 1994; Matyas, 1997).

The statistical model of the gravity equation is written as

$$lnT_{ijt} = \alpha_i + \gamma_j + v_t + x'_{ijt}\beta + \delta FinDev + u_{\mathbf{ijt}}, \quad (1)$$

where $\ln T_{ijt}$ is the logarithmic value of bilateral exports and $\mathbf{x}'_{ijt}$ is a $k\,x1$ row vector of explanatory variables. Subscripts *i*, *j*, and *t*, indicate exporting country, importing country, and year, respectively. All variables in $\mathbf{x}'_{ijt}$ are stated in logarithm form except for the dummy variables. α_i, γ_j and v_t are, respectively, exporter, importer, and time effects. *FinDev* is financial development index which is not log-linearized with trade variable because its values range from 0 to 1. Therefore, the estimated parameters are semi-elasticities.

In empirical work, a number of explanatory variables are included in the row vector $\mathbf{x}'_{ijt}$ including gross domestic product (GDP), population (N), and time invariant variables such as geographic distance, language commonality, border measures, and trade blocs. Following Helpman (1987) and Baltagi *et al*. (2003), our empirical model includes three explanatory variables related to both gross domestic product and population: the sum of bilateral trading partner GDP as a measure of bilateral overall country size ($LGDP_{ijt}$), an relative country size ($LGDPI_{ijt}$), and the absolute difference in relative factor endowments between the two trading partners ($LGDPP_{ijt}$). As in the standard gravity model, the geographical distance between trading partners ($LDIS_{ij}$) is included in the model to represent a proxy of trade costs. We also include the commonality of language to represent cultural familiarity and regional trade agreements (RTA) variables. To measure distance proximity, we include a variable to reflect common borders between trading partners.

Including all variables, our empirical gravity equation can be expressed as follows:

$$\begin{aligned}\mathbf{ln}\boldsymbol{T_{ijt}} &= \alpha_i + \gamma_j + \nu_t + \beta_1 \boldsymbol{LGDP_{ijt}} + \beta_2 \boldsymbol{LGDPI_{ijt}} + \beta_3 \boldsymbol{LGDPP_{ijt}} + \beta_4 \boldsymbol{LDIS_{ij}} \\ &+ \beta_5 FinDev_{it} + \beta_6 \boldsymbol{Language} + \beta_7 \boldsymbol{Border} + \beta_8 \boldsymbol{RTA} + \boldsymbol{u_{ijt}}\end{aligned} \tag{2}$$

where

$$LGDP_{ijt} = Ln(GDP_{it} + GDP_{jt}),$$

$$LGDPI_{ijt} = Ln\left[1 - \left(\frac{GDP_{it}}{GDP_{it} + GDP_{jt}}\right)^2 - \left(\frac{GDP_{jt}}{GDP_{it} + GDP_{jt}}\right)^2\right],$$

$$LGDPP_{ijt} = \left| Ln\left(\frac{GDP_{it}}{N_{it}}\right) - Ln\left(\frac{GDP_{jt}}{N_{jt}}\right)\right|.$$

Language is language commonality that takes a value of one if two trading partners share common language and zero otherwise. *Border* takes a value of one if two trading partners share common border and zero otherwise. *RTA* takes a value of one if a pair of countries takes part in at least one of the same RTA. All other variables are as defined previously.

Estimation Procedures

Different estimators have been proposed to estimate the log transformation of the gravity model. A widely used approach is the fixed effects model (FEM). This approach has been successful in dealing with heterogeneity issues such as the correlation between some of the exogenous variables with the model's error term. However, it does not work for time invariant variables such as distance, common language, and common borders. A second best alternative is to use a random effects estimator, which has an advantage over the fixed effects estimator in that it allows the recovery of the parameter estimates of any time invariant explanatory variables which would otherwise be removed in the fixed effects transformation. A possible drawback is that the random effects model requires that unobserved heterogeneity obey some probability constraints (Green, 2003; Wooldridge, 2002). For example, random effects impose strict exogeneity of and orthogonality between explanatory variables and the disturbance terms (Mundalk, 1978). When there is endogeneity among the right hand side of regressors, the random effects estimators are substantially biased and may yield misleading inferences (Baltagi *et al*. 2003).

A proposed solution to the all or nothing choice of correlation between the individual effects and the regressors is the Hausman-Taylor (HT) estimator (Hausman and Taylor, 1981). The HT estimator allows for a proper handling of data setting when some of the regressors are correlated with the individual effects. The estimation strategy of the HT estimator is based on an instrumental variable estimator which uses both between and within variation of the strictly exogenous variables as instruments (Hausman and Taylor, 1981; Baltagi et al, 2003). The drawback is that HT can only work well if the instruments are uncorrelated with the errors and the unit effects and highly correlated with the endogenous regressors. Although the choice of the strictly exogenous variables is a testable hypothesis, it is often not a trivial task.

Recently, an alternative to no-instrumental variable estimator has been proposed by Plümper and Troeger (2007) which allows estimating the full parameter space that includes both time variant and time invariant variables. The procedure is conducted through decomposing the unit fixed effects (FE) into an unexplained part and a part explained by the time invariant variables and therefore is called fixed effects vector decomposition (FEVD). One major advantage of the FEVD compared to HT model is that the estimator does not require prior knowledge of correlation between the explanatory variables and the individual effects. In addition, FEVD does not require instrumental variables like in the HT estimator. Because of the nature of the data where time-invariant variables are involved and considering its advantages, this study adopts the FEVD approach.

Fixed Effects Vector Decomposition

The fixed effects vector decomposition (FEVD) procedure consists of three steps. Let the data generating process (DGP) be

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \sum_{m=1}^{M} \gamma_m z_{mi} + u_i + \varepsilon_{it}, \tag{3}$$

where the x and z represent vectors of time variant and time invariant variables, respectively, u_i denotes the unit specific effects, ε_{it} is the error term, α is the intercept, and γ and β are parameters to be estimated. The first step of the FEVD approach is to estimate the standard fixed effects model. Averaging (3), we obtain:

$$\bar{y}_i = \alpha + \sum_{k=1}^{K} \beta_k \bar{x}_{ki} + \sum_{m=1}^{M} \gamma_m z_{mi} + \bar{e}_i + u_i, \tag{4}$$

where

$$\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{it}, \quad \bar{x}_i = \frac{1}{T}\sum_{t=1}^{T} x_{it}, \quad \bar{e}_i = \frac{1}{T}\sum_{t=1}^{T} e_{it}.$$

Here, represents the residual of the estimated model. Subtracting (4) from (3) removes the individual effects and the time-invariant variables, shown as follows:

$$\ddot{y}_{it} = \beta_k \sum_{k=1}^{K} \ddot{x}_{kit} + \ddot{e}_{it}, \tag{5}$$

where $\ddot{y}_{it} = y_{it} - \bar{y}_i$, $\ddot{x}_{kit} = x_{kit} - \bar{x}_{ki}$, and $\ddot{e}_{it} = e_{it} - \bar{e}_i$.

Model (5) is used to obtain the unit effects $\hat{u}_i$ where $\hat{u}_i$ includes all time-invariant variables, the constant term, and the mean effects of the time varying variables. Therefore,

$$\hat{u}_i = \bar{y}_i - \sum_{k=1}^{K} \beta_k^{FE} \bar{x}_{ki} - \bar{e}_i , \tag{6}$$

where β_k^{FE} is the pooled OLS estimate of (5).

Step 2 of the FEVD is to regress $\hat{u}_i$ on z to obtain the unexplained part, we call it h_i. That is

$$\hat{u}_i = \sum_{m=1}^{M} \gamma_m z_{mi} + h_i . \tag{7}$$

The last step is to estimate (3) without the unit effects but including the unexplained part h_i using pooled OLS. This model is written as

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \sum_{m=1}^{M} \gamma_m z_{mi} + \delta h_i + \varepsilon_{it} , \tag{8}$$

where $h_i = \hat{u}_i - \sum_{m=1}^{M} \gamma_m z_{mi}$.

DATA

To conduct the analysis, we use annual bilateral export data on agricultural and manufacturing products for a set of 49 countries in the period 1980 and 2008. The bilateral trade data are obtained from UN COMTRADE database with SITC rev.1. The data are expressed in US dollars. We use the SITC definition to construct agricultural products. SITC6 is used to represent manufacturing products. GDP and population are from World Development Indicator (WDI) of the World Bank. GDP is in billion US dollars and population is in millions. The geographical distance is in miles and is calculated between the capital cities of trading partners using the World Atlas. We use OECD data on major regional trade agreements (RTAs) to determine whether pairs of countries take part in a particular RTA. We use CIA World Factbook to assess whether two countries have at least the same official language in order to create the dummy variable Language.

Our financial development indicator is measured using a financial reform index developed by Abiad *et al.* (2010). The index covers 91 countries representing different regions and levels of economic development. The index covers a period of 33 years from 1973 to 2005. For the period of 2006 and 2008, we assume that there was no significant reform in the financial system, therefore the index values of this period are the same as those in 2005. The index is constructed based on seven different dimensions of financial sector policy: (1) credit controls and excessively high reserve requirements, (2) interest rate controls, (3) entry barriers, (4) state ownership in the banking sector, (5) financial account restrictions, (6) prudential regulations and supervision of the banking sector, and (7) securities market policy. Each dimension is coded from zero (fully repressed) to three (fully liberalized), giving a total value ranging from 0 to 21. The index is then normalized in the unit interval.

ESTIMATION RESULTS AND DISCUSSIONS

Financial Development and Trade Flows: Overall Impacts

Table 1 reports the regression results for the standard gravity equation and the extended gravity equation with the augmented financial development variable (*FinDev*) for both agriculture and manufacturing sectors. All parameter estimates in each case reported are statistically significant and all have the expected signs. The overall goodness of fit of the models as measured by adjusted coefficient of determination is about 0.87. For the standard gravity model (first 2 columns), the parameter estimates of LGDP are positive with the magnitudes greater than one suggesting that bilateral exports are elastic with respect to LGDP.

Furthermore, the estimates also indicate that trades in manufacturing sector are more elastic than trade in agricultural sector. Similarly, we found positive effects of LGDPI on the amount of trade between trading partners; but the magnitudes show inelastic values in both agriculture and manufacturing sectors. On the other hand, the estimated coefficients of the relative factor endowment (LGDPP) are negative, suggesting that trade volumes are smaller the more dissimilar two countries are in terms of relative factor endowments.

The coefficient of geographic distance (LDIST) which is usually referred to as the elasticity of trade volume with respect to distance has a negative effect and indicates strong explanatory power with a magnitude of -0.85 and -1.26 in agricultural and manufacturing sectors, respectively. Therefore, bilateral distance reduces trade less than proportionately in the agricultural sector and more than proportionately in the manufacturing sector. Numerically, these estimates suggest that a country will export agricultural products 84 percent more and manufacturing products 125 percent more if that the distance is half the distance of another otherwise-identical market. These estimates are relatively close to the average estimates of distance decay of -0.91 as reported by Disdier and Head (2008).

The common border variable is positive and significant suggesting that adjacent countries trade substantially more than non-contiguous countries. The variable of regional trade agreements (RTA) has a positive sign indicating that trade agreements raise bilateral trade among member countries. Cultural familiarity (Language) has a positive sign indicating that two countries with common language are likely to trade more. Because variables border, language, and RTA are binary and are not log-linearized with trade variable, the effects can be calculated by taking the anti logarithm. Doing so, the effect of the variable border is 34 percent in the agricultural sector and 28 percent in the manufacturing sector. These figures suggest that adjacent countries trade substantially more than non-contiguous countries with its effects confirming the importance of proximity for trade. Trade within RTA members is about

55 percent for agriculture and 23 percent for manufacturing above what could be expected from the gravity model and having the same language is expected to have higher trade by 93 percent and 166 percent in agricultural and manufacturing sectors, respectively.

Table 1. Regression Results: Impacts of Financial Development on Trade

Variable	Standard Gravity Model		Effects of Financial Development	
	Agriculture	Manufacturing	Agriculture	Manufacturing
Intercept	9.233 (0.311)***	7.826 (0.326)***	8.917 (0.312)***	7.494 (0.327)***
LGDP	1.978 (0.054)***	3.096 (0.057)***	1.962 (0.054***	3.077 (0.057)***
LGDPI	0.427 (0.028)***	0.633 (0.029)***	0.431 (0.028)***	0.632 (0.029)***
LGDPP	-0.517 (0.006)***	-0.502 (0.006)***	-0.521 (0.006)***	-0.506 (0.006)***
LDIST	-0.846 (0.009)***	-1.257 (0.009)***	-0.844 (0.009)***	-1.255 (0.009)***
Border	0.296 (0.024)***	0.252 (0.025)***	0.293 (0.024)***	0.249 (0.025)***
Language	0.655 (0.014)***	0.983 (0.015)***	0.655 (0.014)***	0.983 (0.015)***
RTA	0.441 (0.016)***	0.209 (0.017)***	0.441 (0.017)***	0.209 (0.017)***
FinDev	-	-	0.502 (0.047)***	0.548 (0.049)***
Adj. R2	0.869	0.885	0.869	0.885
MSE	1.082	1.171	1.079	1.168
No. of obs.	56,117	55,201	56,117	55,201

Notes: Numbers in parentheses are estimated standard errors; MSE is mean square error, and *** indicates significant at the 1 percent level.

Columns 3 and 4 of Table 1 show the estimation results for the extended gravity equations. As can been seen in Table 1, the inclusion of financial development variable (*FinDev*) did not alter the estimated coefficients included in the standard gravity model. Therefore, the interpretations of the parameter estimates are the same as presented earlier. The main focus is, therefore, on the parameter estimates of financial development. As shown in Table 1, the variable *FinDev* is positive and significantly different from zero. Interpreting the magnitude of the coefficient is not straightforward because *FinDev* is not log-linearized and therefore its estimate indicates semi-elasticity. The quantitative effects are obtained by taking the anti-logarithm similar to the dummy variables. In order to give a more substantive impact of the average impact of variation in financial development, we measure the effects on the basis of one standard deviation from the mean and the outcomes are presented in Table 2.

The first line of Table 2 show the overall impacts derived from Table 1 and the rest are for the regional impacts derived from Table 3 and will be discussed in the following section. As can be seen, our estimates suggest an increase of one standard deviation of financial development index from the mean leads to an increase of approximately 20 percent in agricultural exports and about 23 percent in manufacturing exports. Our data show that the mean of *FinDev* is 0.65 with a standard deviation of 0.37. Therefore, in order to increase agricultural exports by 20 percent or manufacturing exports by 23 percent, the *FinDev* should be increased by 0.37 points from the mean.

The results given in Table 2 also show that the effects of financial development on agricultural sector differ from manufacturing sector; but the magnitude is not substantial, which about three percentage points. It is useful to bear in mind that manufacturing sector is represented by SITC6, therefore it is difficult to fully compare between the two sectors. However, we believe that the results provide some indications that manufacturing sector seems to be more responsive to changing in financial development that agricultural sector, which is in support to Beck's (2002) claims.

Table 2. Impacts of Financial Development of Trade Flows

Country Group	Agriculture	Manufacturing
Overall Impacts	20.42	22.50
Developed country	3.92	-0.27
Developing country	16.90	23.62
Asian	12.73	67.31
Latin America	27.85	9.26
MENA	1.52	58.86
SSA	-15.71	15.84

Note: Numbers are in percent and are based on the change of one standard deviation from the mean.

Financial Development and Trade Flows: Regional Impacts

Table 3 displays the estimation results for the gravity equation with financial development index across country groups included in the estimation. We divide our sample into five country groups or regions: Advanced Countries, Emerging Asia, Latin America, Middle East and North Africa (MENA), and Sub-Saharan Africa (SSA). Dummy variables representing each group are created and the results are multiplied by the financial development index. This interaction term shows the impacts of financial development that occurred in particular country group on trade flows. The results show that the estimated parameters of non financial development variables are all statistically significant and the magnitudes do not differ substantially from the previous estimates as reported in Table 1. The interpretations are similar to previous discussion and therefore will not be discussed in this section. In stead, the discussion will focus on the financial development variables.

As can be seen from Table 3, the effects of financial development on exports vary substantially across country groups and sectors as shown by the magnitudes of parameter estimates that range from -0.77 to 0.88 for agricultural sector and from -0.01 to 2.24 for manufacturing sector. Most of parameter estimates are statistically significant at the 1 percent level. The magnitudes of the parameter estimates do not directly reflect the impacts of a unit change of financial index because they are semi elasticities. Similar to previous discussion, the quantitative effects are obtained from taking the anti logarithm of each coefficient and the results are given in Table 2 above.

Table 3. Regression Results: Regional Impacts of Financial Development on Trade

Variable	Agriculture	Manufacturing
Intercept	8.810 (0.334)***	11.732 (0.349)***
LGDP	1.961 (0.058)***	2.362 (0.061)***
LGDPI	0.462 (0.029)***	0.495 (0.031)***
LGDPP	-0.467 (0.005)***	-0.415 (0.006)***
LDIST	-0.856 (0.009)***	-1.269 (0.009)***
Border	0.298 (0.024)***	0.218 (0.024)***
Language	0.661 (0.014)***	0.984 (0.015)***
RTA	0.458 (0.017)***	0.223 (0.017)***
Financial Development		
Advanced country	0.175 (0.057)***	-0.012 (0.060)
Asia	0.521 (0.086)***	2.238 (0.090)***
Latin America	0.877 (0.052)***	0.316 (0.055)***
MENA	0.054 (0.069)	1.653 (0.072)***
SSA	-0.777 (0.125)***	0.668 (0.145)***
Adjusted R2	0.870	0.887
MSE	1.073	1.146
No. of observation	56,117	55,201

Notes: Numbers in parentheses are estimated standard errors, MSE is mean square errors, and *** indicates significant at the 1 percent level.

In the case of agricultural sector, our estimates as provided in Table 2 show that Latin America has the greatest impact followed by Emerging Asia and advanced country. An increase in the financial development index of one standard deviation from the mean leads to an increase in agricultural exports by approximately 28 percent in Latin America, 13 percent in emerging Asia, and 4 percent in advanced countries. We found that financial development did not significantly affect agricultural exports in MENA countries and had negative impact in SSA region. The insignificant impact in MENA countries can partly be explained by the fact that MENA countries are not the main traders of world agricultural exports. On the other hand, the negative impact of financial development in SSA is likely attributable to the level of implementation. Although there has been some degree of financial reform within SSA countries, they have not been actually implemented or just marginally implemented because of inadequate attention to the institutional foundations of markets and poor financial infrastructure (FAO, 2003). In addition, poor access to markets of SSA producers together with agricultural support measures employed by developed countries has discouraged agricultural exports in the SSA region.

In the manufacturing sector, we found that all estimated coefficients are statistically significant and have the expected signs with the exception of advanced countries. Our estimates suggest that Asian countries have the biggest experience in an increase in manufacturing exports with its magnitude of 67 percent. Financial development in MENA countries has significant and substantial impacts on manufacturing exports, which is contrary to agricultural sector. Our estimates indicate that an increase of one standard deviation from the mean will likely increase manufacturing exports in MENA countries by 59 percent. Similarly, SSA countries do also benefit from financial development with an estimated increase of 16 percent for an increase of financial development index of one standard deviation from the mean. Latin America enjoys a modest increase of approximately 9 percent. We found negative but insignificant impact of financial development in advanced countries. One possible explanation for the insignificant impact of financial development on exports is that the level of financial development index in advanced countries is quite high with an average of 0.95 and most countries have reached the level of full liberalization. Therefore, a change in the financial development index would only have a marginal impact on exports.

Conclusions and Implications

Results indicate a positive impact of financial development on bilateral trade flows. Financial development that occurred in the sample countries seems to have eased the level of credit constraints. Galindo and Schiantarelli (2002), for example, reported that financial liberalization tends to relax financial constraints for firms that were previously constrained in Latin American countries. The implication of the reduced credit constraints is that firms can increase their investment in response to a lowering of variable costs associated with exporting. With lower variable export costs, firms with productivity above a certain cut-off level can become exporters.

Overall, the impacts of financial development on the manufacturing and agricultural sectors are only marginally different but they differ substantially across country groups and sectors when the model included interaction terms of country groups. The impacts on manufacturing sectors are greater than in the agricultural sector in Emerging Asia, MENA, and SSA countries. On the other hand, In Latin America the impacts on the agricultural sector are greater than on the manufacturing sector. In most cases, developing countries (Asia, Latin America, MENA and SSA) experience greater impacts of financial development on exports in both agriculture and manufacturing than in advanced countries.

The results have implications for policy reform in the financial sector as well. The linkages established by this study are of particular importance given the strong relationship between production and trade in most developing countries and provide a solid empirical foundation for pursuing financial reform in those economies in order to stimulate trade and economic growth.

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DOMESTIC TERMS OF TRADE AND RESOURCE TRANSFERS FROM AGRICULTURE: A CASE STUDY OF PAKISTAN

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ABSTRACT

This study has estimated: domestic terms of trade (TOT) for agriculture and its sub-sectors in Pakistan, and implicit taxation of important cropsduring the period 1991-08. The TOT for agriculturethough fluctuating, however, reflect a trend of deterioration over time. Notwithstanding the overall declining trend, agriculture sector experienced improvements in its TOT indices during the 90s; rising from 99.42 in 1990-91 to 109.11 in 1998-99. However, the current decade has witnessed a sharp decline in the TOT index which had fallen to 96.97 by 2007-08. A comparison of the domestic producer prices of major crops with their corresponding international pricesreflects implicit taxation of domestic production during the study period. During 1991-08, annual resource transfers from wheat, basmati paddy, coarse paddy, seed cotton and sugarcane have averaged at $1.25 billion. Resource transfers increased to $1.72 billion per year during 2006-08 with wheat accounting for 81 percent of the total.

JEL Codes: O1 and O2.

Keywords: Agriculture, Domestic Terms of Trade, Pakistan, Resource Transfers.

INTRODUCTION

The agriculture sector holds the key to the success of Pakistan’s development and poverty alleviation efforts. Accounting for 21 percent of the country’s gross domestic product (GDP), employing 45 percent of the labor force, providing the livelihood for 68 percent of the rural population (Government of Pakistan 2008), and supplying raw materials to the country’s major industries and the market for the goods and services of other sectors, agriculture plays a

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multi faceted and crucial role in Pakistan's economy. Thus it is imperative that the country achieve and sustain a high growth rate in agriculture. However, the performance of Pakistan's agriculture sector in the recent past has been erratic, jeopardizing its key role in helping the country to meet the challenges of food security and the government's development and poverty alleviation efforts.

Experience in both Pakistan and other countries have demonstrated that technological change is the major driver of increases in agricultural production and farm incomes. But the adoption of technological change requires not only the availability of technical inputs but also a political and economic environment that encourages investments and favorable output-input price relationships. The prices of farm inputs and commodities influence both the economic environment for production and investments and the level and distribution of income across various groups and regions. However, there are no recent studies evaluating Pakistan's economic environment as it affects input and output prices and the domestic terms of trade (TOT) for agriculture. Moreover, the results of earlier studies on this subject (e.g., Qureshi 1985, Salam 1992) are dated and of little help for current policy planning. The Government's Task Force on Food Security (Government of Pakistan 2009) emphasizes the importance of updating TOT data on a regular basis. While there have been some studies on public policy interventions in commodity markets (Appleyard 1987, Naved, Ijaz and Nasim 1990, Dorosh and Salam 2008, Salam and Mukhtar 2008,) as well as their implication for incentives to agriculture (Dorosh and Salam 2008 , Salam 2009), they do not estimate the resource transfers that arise as a result of such policy measures.

This paper seeks to fill this research gap by using recent data (1991-2008) to assess and analyze the economic environment faced by farmers in Pakistan. There are two stages to the analysis. The first stage estimates the domestic TOT for the agriculture sector and its crop and livestock sub-sectors, which together account for 95-97 percent of agriculture's contribution to GDP. In the second stage of the analysis, the opportunity cost (based on international prices) of producing Pakistan's five major food and cash crops -- wheat, basmati rice , coarse rice , cotton, and sugarcane -- is estimated and compared with the prices received by the domestic producers to assess the magnitude of resource transfers from these crops. These crops account for 64 percent of Pakistan's total annual crop area and about 90 percent of the total value added from major agricultural crops (Government of Pakistan 2008). They are also among the most important commodities for international trade (import and export).

The remainder of the paper is organized as follows. The methodology for estimating both the TOT for agriculture and the resource transfers from the five major crops is described in section 2. The empirical estimates of the domestic TOT for agriculture and its sub-sectors as well as the estimates of resource transfers are presented and discussed in section 3. Section 4 summarizes the main findings and highlights their policy implications.

METHODOLOGICAL FRAMEWORK

This section describes the methodology used to estimate both the TOT for agriculture and the resource transfers from Pakistan's wheat, rice (basmati and coarse paddy), cotton, and sugarcane producers.

Terms of Trade

TOT generally refers to the relationship (or ratio) between the average price of a country's exports and the average price of its imports (Tsakok1990). External TOT is usually used in the context of international trade, while domestic or inter-sectoral TOT refers to the relationship between the prices received by a sector for its outputs and the prices it pays for its inputs. Extending this definition to the agriculture sector, TOT refers to the relationship or ratio between the average prices of agricultural outputs and the average prices of agricultural inputs.

The domestic -- or inter-sectoral -- TOT creates the economic environment and the structure of incentives or disincentives for a given sector. The TOT also determines the direction (i.e., inflow or outflow) of resource transfers to or from that sector. Thus, the inter-sectoral TOT provides helpful information about the economic environment and investment climate for a given sector. However, estimating inter-sectoral TOT requires detailed data on the prices of various outputs (exports) and their respective shares intotal income as well as the prices of inputs (imports) and their respective shares in total expenditures. Unfortunately, reliable data on the relative shares of various outputs and inputs in total farm income and expenditures are not readily available. Moreover, there is a lot of temporal and spatial variation in input and output prices. Thus, estimating theTOT for agriculture and its subsectorsposes both conceptual challenges and practical difficulties. These data challenges were addressed by estimating implicit deflators for agriculture and its sub-sectors. More specifically, an implicit deflator, which is the ratio of nominal GDP to real GDP (Mankiw1999), can be calculated as:

(GDP at current factor cost / GDP at constant factor cost) X 100

Implicit deflators can be calculated for specific sectors of the economy by inserting into the above equation estimates of the value of production for the sector. Because the implicit deflators for GDP and the various sectors (e.g., agriculture) and sub-sectors (e.g., crops, livestock) are based on the total value of all goods and services produced each year, they are the most comprehensive measures/indices available (Tomek and Robinson 1990). This approach also allows the weights on the prices for different goods to change with changes in GDP, unlike the consumer price index (CPI), which assigns fixed weights to goods prices (Mankiw 1999).

The prices received by agricultural producers are indicated by the implicit deflator estimated for the sector. To represent the prices of the inputs and services used in agriculture, an implicit deflator for the total economy minus the agriculture sector (i.e., GDP minus the value of agricultural production) was estimated. Constant factor costs for 1999-2000 were used in the analysis. Estimates of the respective TOT for agriculture and its sub-sectors were calculated as the ratio between the implicit deflator for agriculture (or its sub sectors), which represents the prices received for its outputs, and the implicit deflator for the rest of the economy, which represents the prices paid by agriculture (or its sub-sectors) for its inputs and services, or:

(Implicit deflator for agriculture / implicit deflator for rest of the GDP) * 100

The advantage of using implicit deflators to estimate the TOT, as mentioned above, is the comprehensive nature of the data, for all products of the sector as well as for the prices of inputs and other items used by farm households, not only for agricultural production but also for household consumption.

Resource Transfers

The methodology for estimating the transfer of resources is based on the framework used to estimate the nominal protection coefficient (NPC). That is, NPC = Pdi/ Pwi(Tsakok 1990)], where Pdi stands for domestic price of commodity and Pwi the international price of the commodity. Thus, this formula compares the domestic and international prices of a commodity. International prices indicate the opportunity cost to a country of producing various commodities domestically (Tsakok1990). This means that empirical estimates of NPCs provide an indication of the magnitude of the implicit taxation (protection) -- or the resource transfers from (to) -- the commodity or sector concerned. The focus here is on those crops that are important to Pakistan from an international trade perspective. These are wheat, basmati and coarse rice, cotton, and sugarcane. Salam (2009) estimates domestic producer prices, international prices, and the corresponding NPCs for these crops from 1991 to 2008. The data on domestic and international prices are presented in Annex Table 1. Using these estimates, the deviations between international and domestic prices for each commodity were calculated to identify the rates of implicit taxation or subsidy per metric ton of production and the nature and direction of the resource transfers. Next the estimates of rate of taxation (or subsidy) were combined with data on production and marketing to calculate the value of the total annual resource transfers for each crop. To ascertain the extent of variation in the average values of resource transfers, through implicit taxation, from the commodities under study the coefficients of variation around the mean values for various sub-periods were also calculated and are reported in the discussion on the subject.

RESULTS OF EMPIRICAL ESTIMATION

This section presents the empirical estimates of the domestic TOT for the agriculture sector and its sub-sectors, and the direction and magnitude of resource transfers concerning the five major food and cash crops.

Terms of Trade for Agriculture

The estimated TOT for agriculture and its sub-sectors (i.e., crops, livestock) between 1991 and 2008 is presented in table 1. The aggregate results represented by the TOT indices indicate substantial year-to-year variation, but a general trend over time of deteriorating prices received by farm households relative to the prices paid by them. Based on the pattern depicted by the TOT results, the study period can be divided into two distinct sub-periods: 1990-91 to 1998-99 (the decade of the 1990s) and 2000 to 2008 (the current decade).

Table 1. Terms of trade for agriculture and its sub-sectors

Year	Total Agriculture	Major crops	Minor crops	Crops	Livestock
1990-91	99.42	101.13	133.79	109.57	96.07
1991-92	99.96	105.59	126.88	110.61	96.29
1992-93	103.01	107.25	125.05	112.15	98.28
1993-94	104.97	113.45	122.07	116.01	99.53
1994-95	106.29	117.69	114.51	116.75	101.79
1995-96	96.46	107.67	118.06	110.70	83.61
1996-97	104.97	112.09	110.45	111.60	100.02
1997-98	106.67	118.73	111.89	116.66	99.98
1998-99	109.11	122.20	119.73	121.43	100.07
1999-00	100.00	100.00	100.00	100.00	100.00
2000-01	95.87	96.71	98.41	97.19	94.38
2001-02	95.70	94.13	101.53	96.20	94.83
2002-03	96.45	98.73	93.66	97.36	95.54
2003-04	96.05	100.19	81.01	94.91	97.10
2004-05	94.86	95.83	90.77	94.58	95.00
2005-06	88.20	82.94	88.05	84.24	90.22
2006-07	92.85	87.14	96.50	89.36	94.52
2007-08	96.67	98.56	93.13	97.19	94.82
Annual changes in TOT indices: % per year					
1991-00	0.45	0.79	-2.33	-0.08	0.32
2001-08	-0.44	-0.97	-0.84	-0.95	-0.21
1991-08	-0.67	-1.26	-2.45	-1.59	-0.21

Note: The terms of trade is defined here as the implicit deflator for agriculture and its sub-sectors, Estimated in terms of 1999-00 constant factor cost divided by the implicit deflator of GDP minus agriculture (all sectors other than agriculture).

Source: Author's calculations, based on data from Salam (2009).

Generally speaking, the agriculture sector, particularly the crops sub-sector, seems to have fared much better during the 1990s than during the current decade, as the TOT index for agriculture increased from 99.42 in 1990-91 to 109.11 by 1998-99, but fell thereafter, and was estimated at 96.67 in 2007-08. For the crops sub-sector, the TOT index rose from 109.57 in 1990-91 to 121.40 in 1998-99, but fell to 100.00 in 1999-00, and was estimated to be 97.19 in 2007-08. However, the gains in the TOT for the crops sub-sector during the 1990s were driven by major crops (i.e. wheat, cotton, rice, sugarcane, maize, oilseeds, gram, barley, tobacco, etc.), as minor crops suffered a decline in their TOT even in this period. The livestock sub-sector experienced a marginal improvement in its TOT during the 1990s, but has suffered a deteriorating TOT during the current decade.

As indicated at the bottom of table 1, the average annual change in the TOT for the agriculture sector during the study period (1991-2008) is estimated at (-) 0.67 percent per year. For the crops and livestock sub-sectors, the average annual change in the TOT is (-) 1.59 percent and (-) 0.21 percent, respectively. Nevertheless, during the 1990s, the agriculture sector as a whole experienced an improvement in its TOT, at an average annual rate of 0.45 percent. This improvement was due to gains for major crops and the livestock sub-sector, which recorded average annual TOT improvements at the rates of 0.79 percent and 0.32 percent, respectively. In the current decade, however, there has been deterioration in the TOT for both the crops and livestock sub-sectors.

Implicit Taxes on Major Crops

The estimated implicit taxes or subsidies for the five major crops from 1991-2008 are presented in table 2.

Table 2. Average implicit tax (subsidy) on important commodities

	Wheat	Basmati Paddy	Coarse Paddy	Cotton	Sugarcane
			US $ / metric ton 1991-95		
Mean	38.19	8.14	9.75	170.99	3.68
C.V	0.49	1.45	3.84	0.42	0.71
			1996-00		
Mean	59.26	21.88	-2.89	109.23	-0.52
C.V	0.67	1.19	-7.61	0.47	-6.67
			2001-05		
Mean	86.29	30.32	-7.30	61.40	0.51
C.V	0.13	1.07	-0.97	0.33	3.81
			2006-08		
Mean	127.85	27.70	7.83	27.22	1.25
C.V	0.77	0.28	0.75	1.82	1.99
			1991-00		
Mean	48.72	15.01	3.43	140.11	1.35
C.V	0.64	1.35	8.66	0.48	2.73
			2001-08		
Mean	101.88	29.34	-1.62	48.58	0.79
C.V	0.56	0.85	-6.17	0.72	2.56
			1991-08		
Mean	72.35	21.38	1.18	99.43	1.08
C.V	0.71	1.08	19.15	0.72	2.72

Note: Positive values indicate a tax. Figures in parentheses are negative values, indicating a subsidy.

Source: Author's calculations, based on data adapted from Salam (2009)

There was wide variation in the international prices and thus in the resulting NPCs. To save space, table 2 summarizes the results in five-year sub-periods. Annex table 2 reports data on the average annual implicit taxation (or subsidy) per metric ton of production, converted into US dollars from Pak Rupees, for each year of the study period. The pattern of implicit taxes (or subsidies) for each crop is discussed below.

The producer prices of wheat lagged well behind international prices throughout the study period (see Annex table 1), indicating implicit taxation of domestic producers. The average implicit tax on wheat production experienced a rising trend over time, increasing from $38.19 per metric ton in 1991-95 to $127.85 during 2006-08. However, the increase in the implicit tax on domestic production of wheat is also accompanied by a high variation around the mean value, which means a lot of variation in the yearly values of unit tax. The estimated average tax on domestic wheat production for the entire study period (i.e., 1991-2008) is $72.35 per metric ton, with a coefficient of variation (CV) of 71.00 %

As shown in Annex table 1, domestic producer prices of basmati paddy also lagged behind international prices.Overall, basmati producers experienced an increase in the implicit tax, which rose from $ 8.14 per metric ton in 1991-95 to $ 27. 70 during 2006-08. The average implicit tax rate for basmati for the entire study period is estimated to be $21.38 per metric ton (with a CV of 108 %). For coarse (paddy), the data on domestic and international prices reveal a mixed picture; both implicit taxation and protection during the study period. However, the overall average tax on coarse paddy is estimated at $ 1.18 per metric ton (with a CV of 1915 %). The high coefficient of variation of implicit taxation of coarse paddy also reflects the mixed pattern of its taxation as well as subsidy besides lot of variation in prices of the produce during the reference period.

The domestic seed cotton market appears to have experienced a substantial improvement in tracking international prices over time. Accordingly, implicit taxation of seed cotton declined from an estimated $ 170.99 per metric ton in 1991-95 to only $27.22 during 2006-08. The average annual tax on seed cotton over the study period is estimated at $99.43 per metric ton (with a CV of 72%).

The overall picture for sugarcane during the study period is one of close alignment of domestic and international prices (see Annex table 1). However, the aggregate picture conceals wide yearly fluctuations and divergence between domestic and international prices. Nevertheless, sugarcane has experienced a substantial reduction in implicit taxation, which fell from $3.68 per metric ton during 1991-95 to $ 1.25 per metric ton during 2006-08. For the study period as a whole, the implicit tax of sugarcane averages $1.08 per metric ton. However, since the study period was characterized by both protection and taxation of sugarcane, there is a high CV of 272 %, which reflects a lot of variation around the mean value.

Total Annual Resource Transfers

As discussed in the section on methodology, the average implicit tax rates were used to calculate total resource transfers for each of the five crops. The results are summarized in table 3 and presented in detail in Annex table 3. The data reveal some interesting patterns concerning the outflow of resources from producers of these crops.

Wheat crop which has experienced an increase in taxation over time, appears to have borne the brunt of the large resource transfers from the crop sub-sector. This is due not only to the large quantity of marketed wheat but also because of the increasing wedge between domestic and international wheat prices. Average annual transfers from wheat producers increased steadily during the study period, from approximately $ 304 million during 1991-95 to $ 1,404 million during 2006-08.

Table 3. Annual resource transfers from important crops

	Wheat	Basmati Rice	Coarse Rice	Cotton	Sugarcane	Total
				...000 $...		
			1991-95			
Mean	303,609.54	10,796.36	25,244.25	757,386.06	112,505.48	1,209,541.69
C.V	50.77	141.76	370.39	43.61	67.35	36.09
			1996-00			
Mean	525,197.14	40,108.86	(14,465.12)	501,793.97	(24,306.99)	1,028,327.85
C.V	60.78	123.86	(472.77)	49.68	(430.05)	64.66
			2001-05			
Mean	836,422.80	62,417.41	(21,295.04)	321,129.65	22,326.44	1,221,001.25
C.V	7.95	96.39	(101.17)	43.16	273.75	7.39
			2006-08			
Mean	1,400,496.83	80,043.33	27,068.90	167,669.18	48,981.21	1,724,259.46
C.V	75.67	30.34	78.80	169.22	209.06	53.95
			1991-00			
Mean	414,403.34	25,452.61	5,389.56	629,590.02	44,099.24	1,118,934.77
CV	63.61	149.07	1,484.62	48.76	254.61	48.15
			2001-08			
Mean	1,047,950.56	69,027.13	(3,158.56)	263,581.98	32,321.98	1,409,723.08
C.V.	61.00	69.78	(1,012.00)	76.15	225.68	40.11
			1991-08			
Mean	695,980	44,819	1,590	466,920	38,865	1,248,174
C.V.	80.00	104.98	3,890.93	68.24	242.76	44.42

Note: Figures in parentheses are negative values indicating subsidy while positive values reflect tax or resource transfers.

Source: Calculations by the author from the data given in Annex Table 3.

During the 1990s, the average annual resource transfer from wheat producers was approximately $ 414 million (with a CV of 63.61 %. The annual resource transfer from wheat is estimated to have more than doubled during the current decade (2001-08), to approximately $ 1,048 million (with a CV of 61.00 %). The average value of these transfers over the entire study period is estimated at $696 million per year.

Basmati paddy, which also experienced a rising trend in implicit taxation, also suffered an increasing annual outflow of resources, from approximately $11 million in 1991-95 to $ 80 million during 2006-08.

This resource transfer is estimated to have increased from $ 25 million per year during the 1990s to $ 69 million in the current decade. The 1990s was also characterized by a higher variation in resource transfers, as reflected by its higher CV of 149.07 %, compared to 69.78 % for the current decade.

The average annual resource transfer from basmati paddy producers for the entire study period is estimated at $45 million per year.

For coarse paddy, which enjoyed protection in some years, the overall picture during the study period is one of implicit taxation, or resource transfers away from domestic producers. Average annual resource transfers, estimated at approximately $ 25 million in 1991-95, changed to protection (or implicit subsidy) during 2001-05, averaging $ 21.3 million per year. Nevertheless, 2006-08 was characterized by implicit taxation and thus an outflow of resources, averaging approximately $ 27 million per year, as international prices of rice rose sharply in the wake of the global food crisis. These wide swings and variations in the taxation of coarse paddy are also reflected in its high CV (3890.93%).

Although domestic seed cotton prices have improved in terms of more closely tracking international prices, there was still a substantial outflow of resources from domestic seed cotton producers during the study period.

The annual transfer of resources from cotton farmers declined from an average of approximately $ 757 million per year during 1991-95 to $ 502 million per year during 1996-00, to $321 million over year during 2001-05, and $168 million per year during 2006-08. However, the resource transfers from cotton farmers still averaged $ 466.92 million per year during the entire study period, with a CV of 68.24%.

For sugarcane, which also experienced both protection and taxation during the study period, there was an average resource transfer away from producers of $ 34.53 million per year between 1991 and 2008. However, the CV is very high (276%), which reflects substantial variation in the annual value of resource transfers.

The data suggest that during the first half of the 1990s, domestic production of sugarcane crop was heavily taxed, as annual transfers averaged approximately $ 113 million per year between 1991 and 1995. However, the situation changed during the second half of the 1990s, with sugarcane production receiving an annual subsidy of approximately $ 24 million between 1996 and 2000. But for the decade overall, there was a transfer of resources away from sugarcane producers averaging $ 44 million per year. In the current decade, sugarcane has contributed approximately $ 32 million per year to the outflow of resources from Pakistan’s crop sub-sector.

The data iintable 3 indicate that the implicit taxation of wheat, cotton, basmati paddy, coarse paddy, and sugarcane has resulted in large resource transfers from domestic producers. The total value of annual resource transfers from the five crops combined has ranged from approximately $ 253 million to $ 2,376 million. During the 1990s, total annual resource transfers averaged $ 1,119 million, with cotton producers accounting for 56% and wheat producers accounting for 36% of the total. Thus cotton and wheat together accounted for 92 percent of the total resource transfers from the five crops. The picture has changed dramatically over time, especially concerning the relative size of the resource transfers from cotton and wheat producers. During the 2001-08 period, resource transfers from the five crops increased to an annual average of $ 1,410 million, with wheat accounting for the lion’s share ($1,048 million, or 74%) and cotton accounting for $264 million, or 19% . In the wake of the unprecedented spike in world food prices, total resource transfers from the five crops also rose sharply during 2006-08, to approximately $1,724 million per year.

Caveat: It is important to note that the estimates of total resource transfers depend on the size of the total harvest for each commodity and its marketable surplus. However, there are no firm and reliable estimates of individual crops' shares of marketed production.

Thus the estimates of marketable surplus used in the calculations here represent the best (experts') judgment on the subject. Nevertheless, the estimates of total resource transfers for each crop would change if the underlying assumptions concerning marketed shares of production, as detailed in Annex 3, were to change.

CONCLUSIONS

The results of the analysis indicate that there has been a deterioration over time in the agriculture sector's domestic terms of trade, and hence its purchasing power, as well as an erosion of production incentives for agriculture. Estimates of the TOT for agriculture for the 1991-2008 period reflect some improvement for the sector as a whole during the 1990s but a decline during the current decade. There is an urgent need to reverse this declining trend in TOT through such policy interventions which help raise producer prices in relation to input prices.

The estimates of implicit taxation indicate that there has been a continuous large-scale transfer of resources away from major food and cash crop producers. This "hemorrhaging" of resources has adverse effects on farm investments, agricultural production, and productivity, and jeopardizes the government's economic development and poverty-alleviation efforts.

In order to achieve sustainable agricultural development, it is imperative to arrest the process of resource transfers from major crops and improve the TOT for agriculture and increase incentives to farm production.

Deregulation of domestic and international trade in farm commodities and removing various constraints and obstacles hampering various activities in the domestic markets mayhelp in aligning domestic producer prices with the developments in international commodity markets.

This will go a long way in not only removing distortions in producer incentives but also improve the TOT for agriculture. The resulting improvements in the economic environment should promote farminvestments, adoption of improved agronomic practices and high quality inputs,crucial for achieving arobust and sustainable growth rate in agriculture.

These measures would be helpful in increasing farm production, raise productivity and serve the cause of food security and poverty reduction in the rural country side. In view of the ever changing situation in global and domestic commodity markets it is imperative to build institutional capacity to monitor and analyze these developments and address the emerging policy challenges.

Annex Table 1. Domestic market and international prices of major crops Rs./40 kg)

	Wheat		Basmati paddy		Coarse paddy		Seed cotton			Sugarcane		
Year	Import parity	Domestic market	Export parity	Domestic market	Export parity	Domestic market	Export Parity	Domestic market	Import parity	Export Parity	Domestic market	Import parity
1990-91	144	121	167	143	72	78	464	327	669	NA	NA	NA
1991-92	183	134	167	158	173	98	387	334	581	NA	16.88	21.76
1992-93	193	139	184	190	108	112	383	384	560	NA	18.63	19.75
1993-94	178	170	201	194	100	98	447	497	877	18.48	19.7	25.72
1994-95	219	176	198	192	115	137	918	785	1185	23.48	21.2	35.58
1995-96	349	185	215	231	227	181	816	754	1119	24.58	25	39.98
1996-97	350	273	315	296	161	164	879	793	1204	0	39	37.17
1997-98	346	259	355	297	176	205	821	843	1178	28.05	37	42.76
1998-99	303	261	395	362	195	234	918	914	1046	23.62	34	35.79
1999-00	365	297	481	361	184	203	640	641	1060	31.32	38.5	30.57
2000-01	504	275	477	300	175	180	858	900	1302	NA	47.5	41.36
2001-02	523	292	512	379	202	206	648	761	1017	42.07	42	44.76
2002-03	522	305	509	495	198	218	816	914	1297	27.22	35.5	48.08
2003-04	567	385	515	500	245	257	1136	1219	1583	28	34.5	45.26
2004-05	581	432	565	543	293	338	899	885	1246	40.08	40.5	54.08
2005-06	458	411	615	537	297	290	995	1017	1318	55.56	60	64.57
2006-07	804	437	671	594	325	310	1089	1110	1389	NA	60	69.98
2007-08	1232	750	947	900	561	525	1268	1468	1519	46.5	57.5	66.56

Notes: Import parity stands for import parity price, export parity stands for export parity price, and domestic market stands for domestic market prices.
Source: Salam (2009).

Annex Table 2. Average implicit tax or subsidy per unit of production

Year	Wheat	Basmati paddy	Coarse paddy	Seed cotton	Sugarcane
		US. dollars per metric ton			
1990-91	30.00	26.76	(6.69)	267.03	
1991-92	53.36	9.06	75.47	150.94	4.91
1992-93	56.42	(5.78)	(3.85)	84.26	1.08
1993-94	10.60	5.80	1.66	136.75	1.99
1994-95	40.55	4.86	(17.83)	215.95	6.75
1995-96	125.79	(11.92)	34.26	159.00	5.42
1996-97	56.28	12.18	(1.92)	159.32	(1.17)
1997-98	55.03	33.57	(16.78)	90.58	(0.92)
1998-99	27.55	17.63	(20.84)	36.33	(2.29)
1999-00	31.66	57.95	(9.18)	100.93	(3.65)
2000-01	93.38	75.72	(2.14)	77.00	(2.63)
2001-02	92.57	54.13	(1.63)	29.10	0.58
2002-03	93.52	5.98	(8.55)	60.90	0.92
2003-04	84.33	6.51	(5.21)	61.01	0.92
2004-05	67.66	9.27	(18.95)	78.97	2.77
2005-06	19.02	32.58	2.92	58.26	0.03
2006-07	153.19	31.75	6.18	53.19	4.11
2007-08	211.35	18.79	14.39	(29.78)	(0.39)

Note: Positive values indicate a tax. Figures in parentheses are negative values, indicating a subsidy. Foe seed cotton and sugarcane calculations of implicit tax or subsidy based on the average of import and export parity prices as reported in Annex table 1.

Source: Author's calculations, based on data in Annex table 1.

Annex Table 3. Resource transfers (through implicit taxation) from major crops

Year	Wheat	Basmati paddy	Coarse paddy	Seed cotton	Sugarcane	Total
			(000 US dollars)			
1990-91	218,458	35,230	(15,981)	1,180,234	112,505	1,530,447
1991-92	418,468	10,640	189,466	888,848	121,783	1,629,205
1992-93	455,819	(7,064)	(8,931)	350,373	29,424	819,621
1993-94	80,603	8,016	5,234	505,112	68,009	666,974
1994-95	344,700	7,160	(43,567)	862,363	230,806	1,401,461
1995-96	1,063,332	(19,162)	99,322	773,617	152,630	2,069,739

1996-97	468,553	20,578	(6,160)	685,686	(31,858)	1,136,800
Year	Wheat	Basmati paddy	Coarse paddy	Seed cotton	Sugarcane	Total
1997-98	514,407	51,226	(57,029)	381,995	(37,905)	852,693
1998-99	246,038	31,743	(73,157)	146,655	(98,665)	252,614
1999-00	333,656	116,159	(35,302)	521,017	(105,737)	829,792
2000-01	888,230	137,762	(7,782)	379,442	(77,249)	1,320,402
2001-02	843,613	117,721	(3,641)	141,820	21,140	1,120,653
2002-03	896,976	14,791	(22,368)	285,605	38,394	1,213,398
2003-04	822,196	17,091	(15,030)	281,509	40,382	1,146,147
2004-05	731,100	24,722	(57,653)	517,273	88,965	1,304,406
2005-06	202,354	97,800	9,653	348,292	817	658,916
2006-07	1,784,336	89,962	20,696	314,069	166,585	2,375,648
2007-08	2,214,800	52,368	50,858	(159,353)	(20,458)	2,138,214

Note: Positive values indicate a tax or transfer of resources away from producers. Values in parentheses are negative, indicating an implicit subsidy or transfer of resources to producers.

Source: Author's calculations.

Notes for calculation of production and marketed quantities of commodities for estimating resource transfers reported in Annex table 3:

- *Wheat:* Based on a field survey in irrigated regions, Salam et al (2002) estimated marketable surplus at 55 percent in Punjab and 42 percent in Sindh. In the present study 50 percent of total produce is assumed to be marketed by farmers and the balance retained by farmers for seed, feed and domestic consumption. Wheat marketed at market prices is the difference between 50 percent of total production minus the procurements by government agencies under price support program
- *Seed cotton*: Data on cotton production are reported in terms of lint. Farmers produce and sell seed cotton. Normally ginning out turn (GOT) in Pakistan reported by the ginneries averages 33 percent i.e. seed cotton yields 33 percent cotton. The Agricultural Prices Commission has also adopted this in its parity price calculations. Accordingly, to estimate the quantity of seed cotton from the published data on cotton production the latter was multiplied by three. In consultation with crop experts ten percent of the seed cotton assumed to be retained for seed and other household uses and 90 percent marketed and used in resource transfer calculations.
- *Rice paddy*: Data on rice production reported in terms of cleaned rice kernels. Farmers produce and sell unhusked paddy. The average ratio between cleaned rice and unhusked paddy is generally 66 percent and also adopted by Agricultural prices Commission in its calculations of parity prices. We have also adopted this ration in the calculations to work back the quantity of paddy produced from the data on rice production. In consultation with farmers 25 percent of the produce assumed to be retained for seed and other household uses and 75 percent marketed used in estimating resource transfers. These calculations were performed, separately, for basmati and coarse varieties
- *Sugarcane:* Actual quantity of sugarcane crushed in sugar mills used in resource transfer estimates as reported in Agricultural Statistics of Pakistan and in PSMA's reports for 2005 and 2007.

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