

Exhibit 6

Report from Professor Edward Balistreri

The relative impact on U.S. producers of Crystalline Silicon Photovoltaic Cells of import competition from Korea

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1 Overview

This report uses standard economic analysis to consider the relative importance of import competition from Korea as it relates to market conditions for U.S. producers of crystalline silicon photovoltaic cells, whether or not partially or fully assembled into other products (CSPV). I consider the five years from 2012 to 2016. The analysis is performed using a partial-equilibrium trade model following the model developed by Francois and Hall (1997). The Francois and Hall model is commonly known as the COMmercial Policy Analysis System (COMPAS) model used and documented by the United States International Trade Commission (see USITC, Office of Economics, working paper 2007-12-A). The model is calibrated to data compiled from the USITC questionnaires and uses a set of elasticities consistent with USITC estimates. While the COMPAS model can be used as a tool to determine the relative importance of Korean import competition it is unable to internally assess broader market conditions, which have simultaneously impacted the domestic industry. COMPAS is a limited analytic tool designed to consider import competition in isolation from other important factors. The analysis below should not be viewed as comprehensive. It focuses on the narrow question of relative import competition from Korea, which is an appropriate application of COMPAS.

I find that the *relative* contribution of Korean imports to any domestic injury is small. I estimate that the contribution of Korean import competition relative to ROW import competition is **8.5%** in my central analysis based on the formal economic model.¹ The strong conclusion is that Korean import growth is a less important contributor to any domestic injury during the period of investigation.

The intuition behind my central finding is supported by an examination of the data. Korea played a relatively minor role in import competition across the period of investigation. In fact, for all but the final two years Korean import volumes were in the range of 3% of ROW import volumes. Even looking at 2015 and 2016 in isolation the relative contribution of Korean import competition is much less than import competition from the Rest-of-World

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¹See Table 7 in the following section: 33,155 is 8.5% of 391,112.

(ROW). The largest import increase from Korea was in 2016. While in 2016 the import growth from Korea was substantial its impact on domestic producers was much less than import growth from ROW. In dollar values the Korean import growth is smaller, although roughly in the same range as ROW import growth, but this masks an important fact. Korean imports came in with far less volume at much higher prices, relative to ROW. The ROW import volume increase in 2016 was 38% higher than Korean import volume increases, and the ROW imports were on average entering the US market at 9% lower unit values.² Without doing a formal economic analysis it is clear that much higher volumes at lower prices tip the balance of any potential injury toward ROW imports and away from Korean imports.

Focusing the model-based analysis on the year with the most important import growth from Korea, 2016, my central estimate is that the ratio of injury from Korean import growth relative to ROW import growth was **41%**.³ In 2015, when we observed the most ROW import growth, the importance of Korea is very small at **3.5%**, as it is for all other years in the period of investigation. As indicated above, for the period of investigation (2012 through 2016) the overall contribution of import competition from Korea relative to ROW is **8.5%**. In no case (including substantial sensitivity analysis and alternative structural assumptions) and in no year do I find that Korean import competition is more important than ROW import competition.

The remainder of this report proceeds as follows. In Section 2 I outline the basic analysis and results. This includes an initial consideration of import competition relative to the 2012 market condition, but then continues with a year-on-year analysis that includes the relevant market conditions as they evolve. The model is extended to consider the addition of alternative segments (i.e., the Utility segment) and the implications of advanced (n-type) modules from Korea that increase the differentiation between goods sourced from different regions. In Section 3 I give the algebraic model formulation, and the actual computer code is attached as an appendix. Section 3 along with the code are included to make replication and extensions of my results relatively easy. My vitae is attached as an appendix following the computer code.

2 Analysis

As a first step in the analysis I compile data on domestic shipments of CSPV and imports of CSPV for the years 2012 through 2016, based on the USITC Prehearing Report (Investigation No. TA-201-75) and underlying responses to the USITC questionnaires. This allowed me to calibrate the model and perform policy experiments. The COMPAS structure assumes that differentiated products compete under a Constant-Elasticity-of-Substitution (CES) demand

²ROW imports grew by [] million kW in 2016, and Korean imports grew by [] million kW in 2016. The implied average unit values for Korean 2016 imports was [] per kW and the implied average unit value for ROW 2016 imports was [] per kW. These summary figures are derived from the USITC Prehearing Report (Investigation No. TA-201-75). They can be calculated from Table 1 below.

³See Table 7 in the following section.

system.⁴ There are four differentiated products considered in the base analysis. These correspond to four distinct supply sources:

- Domestic (USD) producers using a majority domestic cells,
- Domestic (USF) producers using a majority imported cells,
- Korea (KOR) producers, and
- Rest-of-World (ROW) producers.

In this analysis we are primarily interested in considering the impact that Korean import competition had on the revenues of USD producers.⁵ Aggregate demand is represented using a constant-elasticity demand function, and supply from each source is represented using constant-elasticity supply functions. This is consistent with the documented COMPAS structure and allows me to adopt the elasticities estimated by the USITC (in the Prehearing Report, Investigation No. TA-201-75) for the CSPV market.⁶ Additional technical documentation of the model structure is presented in the following section, and the computer code used to generate the results is offered in the Appendix to this report. Table 1 presents the base data used in this analysis. It includes the quantity (kW) and value (thousands of dollars) of supply from each source.

2.1 Experiments benchmarked on 2012 market conditions

In the first set of experiments I use 2012 as the benchmark equilibrium and consider that enhanced import competition from all sources has reduced the revenues of U.S. CSPV producers (using domestically sourced CSPV cells—the USD suppliers), and we ask how much of that reduction is due to enhanced import competition from Korea? The model is calibrated to the 2012 data in all years. I then shock the model by imposing the observed import quantities from all sources for each year. At this point I record a reference equilibrium with the total effects of import competition from all importers. The contribution of Korea to this total is then computed by considering an equilibrium where we only consider growth in Korean imports. We also run an experiment where we only consider growth in Rest-of-World

⁴This is commonly referred to as an Armington (1969) structure. Based on Armington’s original suggestion to treat goods sourced from different regions as imperfect substitutes.

⁵I distinguish between producers that use domestic cells and those that use foreign cells because these producers are in different positions regarding import competition and have significantly different input-cost structures. Imports are a key component of the USF supply chain, whereas import competition will most directly impact USD firms. Vertical supply chains and import-domestic complementarities are outside the scope of the basic COMPAS model. These complexities are avoided by acknowledging that USD firms are different than USF firms and assigning them different supply schedules. There are three firms included in USD [], [], and [] as determined from the USITC questionnaire responses. [] was included in the central analysis because it used a majority domestic cells, but it only had a small amount of production in the last year, 2016, and this was used for internal consumption (not shipped to the market). Excluding [] from the USD source would not change the results in a material way. It was simply cleaner to make the distinction of defining USD as firms with a *majority* domestically sourced cells.

⁶My use of the USITC elasticity estimates should not be interpreted as a validation (or endorsement) of the estimates. I adopt these to be consistent. Of particular note, the supply elasticities as estimated by the USITC seem to be in a much higher range than I would expect.

Table 1: US market supply and revenue by source

Quantities (kW)					
	2012	2013	2014	2015	2016
USD	[]	[]	[]	[]	[]
USF	[]	[]	[]	[]	[]
KOR	[]	[]	[]	[]	[]
ROW	[]	[]	[]	[]	[]

Value (\$1,000)					
	2012	2013	2014	2015	2016
USD	[]	[]	[]	[]	[]
USF	[]	[]	[]	[]	[]
KOR	[]	[]	[]	[]	[]
ROW	[]	[]	[]	[]	[]

Compiled from the USITC Prehearing Report augmented with the raw questionnaire data provided by Curtis.

Table 2: Domestic (USD) revenue impacts (\$1,000) relative to 2012

Source of						
Import Competition	2012	2013	2014	2015	2016	Total
All Importers	0	-62,079	-112,048	-158,282	-173,929	-506,338
Korea (KOR)	0	-119	-2,674	-10,016	-49,920	-62,729
Rest-of-World (ROW)	0	-60,475	-108,948	-155,608	-168,078	-493,107

Author's calculations.

imports. Table 2 presents the USD industry revenue impacts in each of these equilibria. It is clear from these results that, using 2012 as a benchmark, import growth from Korea is less important than import growth from ROW. The revenue impact from ROW import growth over the period of investigation is on the order of eight times larger than the revenue impact from Korean import growth.

This relative comparison, of import effects, is valid even if we acknowledge the limited ability of the COMPAS analytic framework in its absolute accuracy and its ability to ranking other factors that will have affected the domestic producers. As a reminder, we should use caution in interpreting the absolute numeric results in Table 2 (and those that follow). The numeric values of domestic revenue impacts should not be taken literally as an empirical measurement. These figures are model generated, but the model does not internally capture many of the factors that contribute to outcomes. The dollar value of revenue changes represented in Table 2 are indications from the COMPAS structure, which can easily establish the relative importance of different import sources but is not designed to measure impacts from simultaneously structural shifts.⁷ COMPAS is a model designed to consider comparative-

⁷In subsequent analysis, in section 2.2, we control for changing market conditions over time through

static experiments. In that role it can give us a good indication of the relative importance of the various import sources, but I have less confidence in the accuracy of the magnitudes. I caution against applying these magnitudes in a literal comparison that moves beyond the COMPAS framework.

In Table 2 competition among the importers plays an important role in determining outcomes. Notice in Table 2 that the sum of the components (KOR plus ROW) do not equal the total impact. This is fundamentally because the model dictates non-linear responses. The added distortions (relative to the 2012 equilibrium) interact in a non-linear manner. This indicates that there are alternative measures of the relative impact of KOR versus ROW. In a simple comparison we might ask what is the marginal impact of adding the import growth with no constraint on the other trade partner? Over the whole period of investigation the Korean impact on domestic firm revenue was only 13% of the ROW impact (62,729 is 13% of 493,107). Even if we focus on the most recent years we see that the Korean impact was 6% of the ROW impact in 2015 (10,016 is 6% of 155,608) and 30% of the ROW impact in 2016.

Alternatively we might ask what is the marginal impact of adding Korean import growth to a benchmark that already includes ROW growth? In this case (because of the non-linearity) the KOR share of the impact is much less, even in the most recent years: 2% in 2015 (158,282-155,608 is 2% of 158,282) and 3% in 2016. In this case adding Korean import growth to a world that already has ROW import growth largely reduces the value of net payments for ROW imports, but only has a minor impact on domestic revenues.

Contributing to the results in Table 2 is the fact that when we impose ROW import growth they displace product from all sources. In the ROW row of Table 2, for example, Korean import volumes will be at a level below their 2012 levels because they experience increased competition from ROW. We can take a more conservative approach to looking at the relative impact of Korean import competition by imposing a constraint that maintains KOR import volumes at 2012 levels when we impose ROW import growth (and maintains ROW import volumes at 2012 levels when we impose KOR import growth). These results are presented in Table 3.⁸ Even in this case, where we exaggerate the marginal impact of Korean import growth alone (because we are artificially supporting ROW imports) the Korean impact is 12% of the ROW impact in 2015, and 46% of the ROW impact in 2016.

The overall conclusion from the initial results presented in Tables 2 and 3 is that Korean import competition had less of an impact on domestic revenues than Rest-of-World import competition. This finding is generated in a simple COMPAS style model that is founded in economic principles. We adopt the elasticities estimated by the USITC (in the Prehearing Report Investigation No. TA-201-75). While the argument that Korean import competition is a less important contributor to any domestic injury is already compelling, under the economic principles applied above, augmenting the analysis with realistic features of the

an exogenous recalibration of the parameters, but this does not identify the drivers of changing market conditions nor does it measure their importance for revenue outcomes. We must acknowledge the inherent limitations of the COMPAS structure as an empirical tool and caveat the measures outcomes.

⁸Notice in Table 3 that the non-linearity is qualitatively well identified because there is no reduction in imports of the other trade partner. The sum of the components is always greater than the total impact.

Table 3: Domestic (USD) revenue impacts (\$1,000) relative to 2012 (other-partner imports constrained to 2012 levels)

Source of Import Competition	2012	2013	2014	2015	2016	Total
All Importers	0	-62,079	-112,048	-158,282	-173,929	-506,338
Korea (KOR)	0	-226	-5,037	-18,286	-77,446	-100,995
Rest-of-World (ROW)	0	-61,943	-110,437	-156,349	-168,549	-497,278
Author’s calculations.						

market will add strength to this position.

2.2 Experiments benchmarked on yearly market conditions

The first model extension that I explore is the impact of changing market conditions over the period of analysis. Over time there are fundamental changes that indicate an evolution of the partial-equilibrium parameters. For example, aggregate demand for CSPV might grow or shrink as the price of substitute energy sources fall or rise over time. This cannot be explained within the COMPAS partial-equilibrium structure, but it can be captured as a set of parametric shift in the demand curve. In addition to demand changes, input cost will impact supply curves, and product mix and efficiency changes in the products from different sourced will change the CES (Armington) aggregation. If, for example, a Korean producer brings on a more efficient technology based on n-type cells (as we know LG did) then market demand will shift toward Korean imports independent of price changes. Again this is not something that can be explained within COMPAS as an internal outcome, but it can be represented in the model as a parametric shift in the calibration of the CES demand system. The market outcomes are observed and this implies a set of calibration parameters. In what follows I consider the relative impact of Korean import competition on the domestic industry, while allowing for the evolution of other market conditions.

To establish a meaningful benchmark that includes these parametric adjustments we use the observed evolution of all market data as established in Table 1, including import growth and implied price trajectories.⁹ In each year the parameters are calibrated such that the model replicates the data as an equilibrium. Thus, an increase in the relative efficiency of Korean modules would appear as an increase in the CES aggregation weight on Korean imports. This gives us a benchmark that accurately represents the data.

To consider potential injury to the domestic producers we consider what their revenues would have been had imports not grown relative to the most recent year. Thus damages in 2015 are based on the difference between USD revenues under imports capped at 2014 levels and the observed USD revenues. This gives us a year-on-year measure of injury that accounts

⁹Consistent with standard calibration practices (Francois and Hall, 1997) units are chosen such that initial prices (in 2012) are one, so we only need the trajectories for computation. All results presented here, however, are converted back to natural units (kW, \$1000, and \$/kW) as established in the USITC questionnaires.

Table 4: Domestic (USD) Year-on-Year revenue impacts (\$1,000) incorporating yearly market conditions

Source of Import Competition	2012	2013	2014	2015	2016	Total
All Importers	0	-73,991	-160,753	-314,342	-226,018	-775,104
Korea (KOR)	0	-76	-2,902	-6,557	-38,161	-47,695
Rest-of-World (ROW)	0	-69,999	-140,796	-248,651	-73,246	-532,691

Author's calculations.

for the growth in imports, but incorporates all of the parametric adjustments that occurred through the period of analysis. Table 4 shows the results of this analysis. For the entire period of investigation the ratio of year-on-year impacts from Korean import competition to the impacts from ROW import competition is 9% (47,695 is 9% of 532,691). Notice again that the impacts in Table 4 are non-linear in that the sum of the components does not equal the impact of imposing both constraints. In this case because we are imposing a cap on imports equal to the previous year imports (rather than artificially growing imports from their 2012 levels) the distortion necessarily compounds. That is, the total impact of caps on both KOR and ROW always exceeds the sum of the impacts from each import cap alone. This is true for all subsequent analysis in this report.

In Table 4 focusing just on 2016 (the year with the largest Korean import growth) we still see that the relative importance of Korean import growth is not as large as ROW import growth. This is attributed to the basic fact that, while the dollar value of the import increases are comparable, the ROW import volume increase was much larger at lower prices. The bottom line conclusion using a relatively simple aggregate model is that the ratio of damage from Korean imports to the damage from ROW imports is at a maximum of 52% for the year 2016 looked at in isolation. In all other years the ratio is much less. As outlined below there is a compelling argument that this exaggerates the Korean contribution, because it artificially aggregates different segments of the market and does not consider the value of the unique technologies that are embodied in the new Korean imports.

Note that when we consider the year-on-year comparison (including those that follow in the remainder of this report) it is generally inappropriate to consider the total "All Importers" revenue impact less the ROW impact as the Korean impact. Again there is a non-linearity, but in the year-on-year comparisons this type of interpretation would conflate Korea's marginal impact with the distortionary impact of the ROW cap (which is artificially imposed). The model is already calibrated to the current market conditions, and thus includes the ROW import growth in the year of analysis. This is in contrast to the comparisons under the 2012 benchmark (Tables 2 and 3) where we were looking at alternative worlds that included ROW and Korean import growth. With the 2012 benchmark it is not clear what the reference should be in attributing impacts to Korea. Should the reference include hypothetical ROW import growth relative to 2012, or not? In the case of the year-on-year analysis it is clear that the benchmark market conditions include ROW imports at their

Table 5: Sensitivity Analysis: Ratio of injury from KOR to injury from ROW

Elasticity	Setting			Ratio (KOR/ROW)		
	Low	Med.	High	Low	Med.	High
Demand (η)	-1.00	-1.25	-1.50	47%	52%	57%
Armington (σ)	3.00	4.00	5.00	62%	52%	47%
USD Supply (μ_{USD})	4.00	5.00	6.00	52%	52%	52%
USF Supply (μ_{USF})	4.00	5.00	6.00	52%	52%	52%
KOR Supply (μ_{KOR})	6.00	7.00	8.00	51%	52%	53%
ROW Supply (μ_{ROW})	6.00	7.00	8.00	54%	52%	51%

Author's calculations.

observed level so simply looking at the Korea row in Table 4 gives us an accurate indication of the impact of Korean import growth.

Prior to considering extensions to the basic framework it is useful to consider the role of elasticities, which are the critical response parameters. Table 5 reports the 2016 ratio of injury attributed to Korea over the injury attributed to ROW for the range of elasticities estimated in the USITC Prehearing Report (Investigation No. TA-201-75).¹⁰ In the central case (consistent with Table 4) the impact of Korea is 52% of ROW in 2016. We see that this result is robust within the range of elasticities considered by the USITC. The ratio is most sensitive to the Armington elasticity with the highest ratio recorded as 62% with a low Armington elasticity (this extreme value is still well below 100%, which would indicate that ROW is less important than Korea). The high relative value of Korea in this run is due to the fact that the denominator of the ratio (injury from ROW alone) falls by more than the relatively smaller Korean impact. Lower Armington elasticities do reduce the absolute impact on domestic revenue in all cases, but in this case it increases the relative impact attributed to Korea.

2.3 Incorporating Multiple Segments

In this section of the report I consider the incorporation of multiple CSPV segments. It is clear from the data that the utility segment is different than the rest of the market. Much of the import growth was in the utility segment. A segment with limited domestic participation. We show that including the consideration of multiple market segments substantially reduces the overall injury to the domestic industry from import competition. Extending the model to consider the high-efficiency *n-type* modules produced in Korea for the non-utility segment shows a clear shift in the relative injury away from import competition from Korea.

To calibrate the model to multiple segments additional data are needed. The quantity data reported in the USITC importer and domestic-firm questionnaires include a breakout by segment. Unfortunately these are not paired with value data. I make the simplest assumption possible: that the unit values are the same across segments. Better information

¹⁰My use of the USITC elasticity estimates should not be interpreted as a validation of their estimates.

Table 6: Domestic (USD) Year-on-Year revenue impacts (\$1,000) with multiple segments (Utility and Other)

Source of						
Import Competition	2012	2013	2014	2015	2016	Total
All Importers	0	-73,014	-143,278	-319,364	-144,175	-679,831
Korea (KOR)	0	-97	-3,859	-8,120	-31,409	-43,486
Rest-of-World (ROW)	0	-68,576	-123,213	-247,012	-58,412	-497,213

Author’s calculations.

might be incorporated if it were available, but I do not expect that this would change my overall conclusions and would likely have a minor impact on the quantitative outcomes. In addition to the quantity and price data, we need an elasticity of substitution across segments (in the top-level nest of the demand system). This is naturally bound between the absolute value of the demand elasticity and the Armington elasticity to avoid the net-complements problem referred to as the “Henning conundrum” by Francois and Hall (1997). For my central analysis I assume the elasticity of substitution between segments is 2.5 ($\sigma^T = 2.5$), and I vary this by ± 0.5 in sensitivity analysis.

Table 6 reports the year-on-year revenue impacts for domestic (USD) firms when we distinguish the utility segment from other CSPV. This appropriately reduces the head-to-head competition in the separate segments and lowers the overall measured revenue reductions. Comparing these results to Table 4 we see that in 2016 revenues are only 64% of the revenue losses reported when we fail to consider utility sales as a separate segment (as reported above in Table 4).

The revenue reductions attributed to Korea in 2016 is also substantially reduced. It is still clear that the only year that Korean import competition rivals that of other importers is 2016, and in that year the base impact of Korea is still only about one-half of the ROW impact (54%). For the whole period of investigation the impact from Korea is only 9% of the impact from ROW.

An additional consideration, now that we have a model with multiple segments, is that the elasticity of substitution may vary across segments. It has been argued that non-utility Korean import growth is largely a result of LG’s innovative, *n-type*, modules with higher efficiency ratings. This suggests that the elasticity of substitution in this segment should be lower. In Table 7 we make a parallel set of model runs but reduce the Armington elasticity of substitution in the non-utility segment from a central value of 4 to 3. This, again, indicates a lessening of import competition. In Table 7 the revenue impacts are further reduced with proportionally more reduction in the Korean impact. For the period of investigation the impact of import competition from Korea is 8.5% of the impact of import competition from ROW (33,155 is 8.5% of 391,112). Even looking at 2016 in isolation we see that the impact of import competition from Korea is 41% of the impact of import competition from ROW. The central conclusion is that import competition from Korea is a less important contributor to any domestic injury. Consistent with all of my analysis, I find that import competition

Table 7: Domestic (USD) Year-on-Year revenue impacts (\$1,000) with multiple segments (Utility and Other) and n-type module considerations

Source of Import Competition	2012	2013	2014	2015	2016	Total
All Importers	0	-52,964	-109,903	-225,125	-117,790	-505,781
Korea (KOR)	0	-75	-2,992	-6,549	-23,539	-33,155
Rest-of-World (ROW)	0	-50,826	-97,655	-185,046	-57,585	-391,112

Author's calculations.

Table 8: Multi-segment Sensitivity Analysis: 2016 ratio of injury from KOR to injury from ROW

Elasticity	Setting			Ratio (KOR/ROW)		
	Low	Med.	High	Low	Med.	High
Demand (η)	-1.00	-1.25	-1.50	32%	41%	52%
Segments (σ^T)	2.00	2.50	3.00	76%	41%	26%
Armington (σ_{UTL})	3.00	4.00	5.00	41%	41%	41%
Armington (σ_{OTH})	2.00	3.00	4.00	10%	41%	54%
USD Supply (μ_{USD})	4.00	5.00	6.00	41%	41%	41%
USF Supply (μ_{USF})	4.00	5.00	6.00	41%	41%	41%
KOR Supply (μ_{KOR})	6.00	7.00	8.00	41%	41%	41%
ROW Supply (μ_{ROW})	6.00	7.00	8.00	42%	41%	40%

Author's calculations.

from Korea is a less important factor.

As indicated in the discussion above (in the context of Table 4) for these year-on-year comparisons benchmarked to the yearly conditions, it is generally inappropriate to consider the total “All Importers” impacts less the ROW impacts as somehow indicating the Korean impact. This would attribute the distortionary impact of the ROW import cap, in error, to Korea. The benchmark already includes ROW import growth. To get an accurate measure of the Korean impact we simply look at the impact of the Korean import cap. This is fully captured in the Korean row of Table 7. See the discussion above for additional details.

The results in Table 7 are, of course, dependent on the full set of elasticities. Sensitivity analysis over the elasticities shows which of these are most important. Table 8 reports the ratio of injury attributed to Korea over the injury attributed to ROW for the range of elasticities estimated by the USITC in the Prehearing Report (Investigation No. TA-201-75), with a correction to reduce the Armington elasticity of the non-utility segment by one point.¹¹

I consider one final model extension as a check on my overall conclusion that Korea is a less important contributor to the domestic impacts. The ROW region, as I have defined

¹¹My use of the USITC elasticity estimates should not be interpreted as a validation of their estimates.

Table 9: Domestic (USD) Year-on-Year revenue impacts (\$1,000) with multiple segments (Utility and Other), n-type module considerations, and Malaysia disaggregated from ROW

Source of Import Competition	2012	2013	2014	2015	2016	Total
All Importers	0	-58,639	-104,811	-250,025	-127,657	-541,132
Korea (KOR)	0	-75	-2,992	-6,549	-23,539	-33,155
Malaysia (MYS)	0	-11,074	-376	-48,969	-27,802	-88,221
Rest-of-World (ROW)	0	-24,730	-75,998	-66,204	-12,850	-179,783

Author's calculations.

it, includes a number of countries, and it is useful to consider how other single countries compare to Korea. In Table 9 I reaggregate the data to pull out Malaysia as a separate importer. Over the full period of investigation the impacts from Korea, -\$33M, are less than the impacts from Malaysia, -\$88M. Even in the year with the most import growth from Korea (2016), import competition from Malaysia turns out to have a larger impact. In only one year, 2014, do we see that the impact of Korean import growth is more than Malaysian import growth, and in that year the impacts for both Malaysia and Korea are swamped by substantial import growth by other partners. It would be relatively easy to pull out a different trade partner in 2014 to show that Korea is less important than a different importer contributing to the domestic revenue impacts. Furthermore, notice that once a single country is disaggregated its marginal impact does not change with additional disaggregations. The Korean row of Table 9 is the same as the Korean row of Table 7. Thus, Korea will always be less important than Malaysia (except in 2014) for all regional aggregations that include Korea and Malaysia as single countries. The conclusion that Korea is a less important contributor to the domestic impacts is supported and, in fact, substantially reinforced when we consider Malaysia as a separate import source.

3 Model Structure

This section outlines the algebraic structure of the model used in the analysis. The model is adopted from Francois and Hall (1997), which documents a standard spread-sheet application of what is known as the COMmercial Policy Analysis System (COMPAS) model. The model used here is formulated as a Mixed Complementarity Problem (MCP) using the General Algebraic Modeling System (GAMS) software (GAMS Development Corporation, 2013). This offers significant computational advantages and structural flexibility that are not available in spread-sheet formulations. The model code appears below in the Appendix. The algebraic formulation follows closely the presentation on page 139 of Francois and Hall (1997), with an extension to potentially consider different market segments.

First we define the indexes associated with parameters and variables. Consider that the demand for CSPV products produced in the U.S. and imported are given by a differentiated products, Armington (1969), structure. Let the types of goods be indexed by

$r \in \{\text{USD}, \text{USF}, \text{KOR}, \text{ROW}\}$, where

- USD: indicates US producers using a majority domestic cells,
- USF: indicates US producers using a majority imported cells,
- KOR: indicates imports from KOR, and
- ROW: indicates imports from other countries.

Each of these product sources might serve different segments (e.g., the utility segment). Let us index these potential segments by $i \in I$ where currently we consider only the utility and other segments $I = \{\text{UTL}, \text{OTH}\}$. Finally, consider that we will want to consider the market outcomes as annual snapshots over the periods of investigation $t \in \{2012, 2013, 2014, 2015, 2016\}$.

Fundamentally, the proposed Armington structure relies on a Constant-Elasticity-of-Substitution (CES) aggregation of the differentiated products in each segment. Let X_{irt} denote the quantity of differentiated product from r in segment i in period t . The aggregate quantity, Q_{it} , is then given by

$$Q_{it} = \phi_{it} \left[\sum_r \alpha_{irt} X_{irt}^{\rho_i} \right]^{1/\rho_i}, \quad (1)$$

where ϕ_{it} is a scale parameter indicating total productivity and the α_{irt} are CES distribution parameters indicating relative productivity ($\sum_r \alpha_{irt} = 1$). The parameter ρ_i indicates substitution, where $\sigma_i = 1/(1 - \rho_i)$ is the constant elasticity of substitution.

In applied economic analysis it is often more convenient to represent the CES aggregation in its *dual form* because this embeds the optimizing behavior of the economic agents. In the dual form the aggregate price index Z_{it} is a function of the differentiated-product prices, P_{irt} :

$$Z_{it} = \frac{1}{\phi_{it}} \left[\sum_r \alpha_{irt}^{\sigma_i} (\tau_{irt} P_{irt})^{1-\sigma_i} \right]^{1/(1-\sigma_i)}. \quad (2)$$

Z_{it} is a price index that represents the minimized cost of a unit of Q_{it} . The instrument τ_{irt} is included in equation (2) which is one in the benchmark, but can be adjusted as a wedge between the net and gross price to hit a specific import target. Thus, in an experiment where we cap Korean imports at last years level $\tau_{i,\text{KOR},t}$ would take on a value above one. This is operationalized by making the specific τ an endogenous variable and adding a constraint to the model. An equivalent experiment can be performed by replacing the Korean supply function with an inelastic function that gives quantity supplied equal to the target. The formulation with τ , however, is cleaner and more flexible because it allows for measurement of both the net (P_{irt}) and gross ($\tau_{irt} P_{irt}$) prices given the specified supply function and accommodates consistent slack constraints (non-binding caps) should they emerge. See the GAMS code for additional details on the MCP formulation.

Applying the envelope theorem to equation (2) scaled up to an expenditure function (by multiplying Q_{it}) we can derive compensated demand for each of the differentiated products:

$$X_{irt} = \phi_{it}^{\sigma_i-1} Q_{it} \left[\frac{\alpha_{irt} Z_{it}}{\tau_{irt} P_{irt}} \right]^{\sigma_i}. \quad (3)$$

Defining a constant-elasticity supply schedule (with elasticity μ_{ir}) we have market clearance (supply = demand) for each of the goods:

$$k_{irt}^S (P_{irt})^{\mu_{ir}} = X_{irt}, \quad (4)$$

where k_{irt}^S is a constant.

Next let us turn to aggregate demand. Consider that each of the segment quantities are combined into an aggregate good, denoted Y_t , in a top-level CES aggregation. In dual form this can be represented as

$$P_t^Y = \frac{1}{\psi_t} \left[\sum_i \beta_{it}^{\sigma_y} Z_{it}^{1-\sigma_y} \right]^{1/(1-\sigma_y)}, \quad (5)$$

where we have scale, distribution, and substitution parameters: ψ_t , β_{it} , and σ_y . Demand for each of the segment aggregates is given by

$$Q_{it} = \psi_t^{\sigma_y-1} Y_t \left[\frac{\beta_{it} P_t^Y}{Z_{it}} \right]^{\sigma_y}. \quad (6)$$

Total demand is assumed to be of the constant-elasticity form so aggregate market clearance is given by

$$Y_t = k_t^D (P_t^Y)^\eta. \quad (7)$$

The set of equation, equations (2) through (7), form a non-linear system that can be used to solve for the endogenous variables Y_t , P_t^Y , Q_{it} , Z_{it} , X_{irt} , P_{irt} .¹² In all reports I adopt the convention that prices and quantities are measured on the input side of the non-linear aggregation (prices are given by P_{irt} and quantities are given by X_{irt}). The instrument τ_{irt} is set endogenously to achieve the specific import quantity targets.

References

Armington, Paul S. (1969) ‘A theory of demand for products distinguished by place of production.’ *Staff Papers (International Monetary Fund)* 16(1), 159–178

¹²Given that the variables are strictly positive the equations are arranged as inequality constraints in the Mixed Complementarity Problem (MCP). This associates specific positive variables with variational inequalities. See the GAMS code for the implementation, and Rutherford (1995) for the basic structure of MCPs as they apply to economic equilibrium problems.

- Francois, Joseph F., and H. Keith Hall (1997) ‘Partial equilibrium modeling.’ In *Applied Methods for Trade Policy Analysis*, ed. Joseph F. Francois and Kenneth A. Reinert (Cambridge University Press) chapter 5, pp. 122 – 155
- GAMS Development Corporation (2013) ‘General Algebraic Modeling System (GAMS) Release 24.2.1.’ Washington, DC, USA
- Rutherford, Thomas F. (1995) ‘Extensions of GAMS for complementarity problems arising in applied economic analysis.’ *Journal of Economic Dynamics and Control* 19(8), 1299–1324

Appendix A: GAMS Code

```

1 $Title COMPAS-style partial-equilibrium model of trade and production of CSPV Modules
2
3 $ontext
4 Model prepared by Edward J. Balistreri (ebalistr@iastate.edu) for:
5     Curtis, Mallet-Prevost, Colt & Mosle LLP (101 Park Avenue, New York, NY 10178)
6     Contact: James P. Durling (jdurling@curtis.com)
7
8 We consider the potential impacts on the US industry of South Korean (KOR)
9 import growth in Crystalline Silicon Photovoltaic (CSPV) Cells and Modules,
10 and the relative importance of KOR versus other factors that may have
11 contributed to revenue impacts on the US CSPV industry.
12
13 We use respondent data from the USITC investigation. Totals are consistent with
14 the USITC compilation in the Prehearing Reports. Segment (Utility) decomposition,
15 as well as the split between US producers using US produced cells (USD) versus US
16 producers using foreign cells (USF), is based on the APO questionnaire data provided
17 by Curtis.
18
19 Elasticities are taken from USITC CSPV Title VII reports
20     eta          demand elasticity          -1 to -1.5,
21     sig          Armington elasticity of substitution      3 to 5
22     mu          supply elasticity          6 to 8
23 Note: Domestic supply elasticities were updated to be
24     consistent with the USITC Prehearing Report: mu_usa = 4 to 6.
25
26 $offtext
27
28 *          We use environment variables to set the elasticities to
29 *          facilitate batch-file sensitivity analysis. Defaults are
30 *          at the center of the USITC ranges
31
32 $if not set eta          $set eta -1.25
33 $if not set sig1        $set sig1 4.00
34 $if not set sig2        $set sig2 3.00
35 $if not set sigT        $set sigT 2.50
36 $if not set muusd       $set muusd 5.00
37 $if not set muusf       $set muusf 5.00
38 $if not set mukor       $set mukor 7.00
39 $if not set murow       $set murow 7.00
40
41 Sets
42     t time periods          /2012,2013,2014,2015,2016/,
43     r supply sources (types of firms) /USD,USF,KOR,ROW/,
44     i market segments /UTL,OTH/,
45     usa(r) domestic subset /USD,USF/,
46     t0(t) initial period /2012/
47

```



```

48 *      define these subsets to avoid annoying quotes
49      usd(r) US firms using US cells          /usd/,
50      usf(r) US firms using foreign cells      /usf/,
51      kor(r) Korean firms                     /kor/,
52      row(r) ROW firms                        /row/
53 ;
54
55 Alias (r,rr), (t,tt), (i,ii);
56
57 *      Read in the data from Excel "APO_data_revised.xlsx" to
58 *      create APO_data_revised.gdx
59 *      These data are "revised" to be consistent with USITC
60 *      Prehearing Report totals. Segment (Utility) data are
61 *      compiled from the raw questionnaire data (provided by
62 *      Curtis)
63 $include gdxgen.gms
64
65 $gdxin APO_data_revised.gdx
66
67 Parameter
68     usd_q(i,t) Shipment quantity (kW) US firms using US cells
69     usf_q(i,t) Shipment quantity (kW) US firms using foreign cells
70     kor_q(i,t) Shipment quantity (kW) Korean imports
71     row_q(i,t) Shipment quantity (kW) ROW imports
72     usd_v(i,t) Shipment value ($1000) US firms using US cells
73     usf_v(i,t) Shipment value ($1000) US firms using foreign cells
74     kor_v(i,t) Shipment value ($1000) Korean imports
75     row_v(i,t) Shipment value ($1000) ROW imports
76     auv(i,r,t) AUV ($ per kW)
77 ;
78
79 $load usd_q usf_q kor_q row_q usd_v usf_v kor_v row_v
80 $gdxin
81
82 display usd_q,usf_q,kor_q,row_q,usd_v,usf_v,kor_v,row_v;
83
84 *      Note: currently AUVs are the same across segments
85 *      because the USITC did not report/collect AUVs by segment.
86 auv(i,usd,t)$usd_q(i,t) = usd_v(i,t)*1000/usd_q(i,t);
87 auv(i,usf,t)$usf_q(i,t) = usf_v(i,t)*1000/usf_q(i,t);
88 auv(i,kor,t)$kor_q(i,t) = kor_v(i,t)*1000/kor_q(i,t);
89 auv(i,row,t)$row_q(i,t) = row_v(i,t)*1000/row_q(i,t);
90
91 display auv;
92
93 Parameter echoq(i,r,t)      quantities (kW), echov(i,r,t) values ($1000);
94 echoq(i,usd,t) = usd_q(i,t);
95 echoq(i,usf,t) = usf_q(i,t);
96 echoq(i,kor,t) = kor_q(i,t);
97 echoq(i,row,t) = row_q(i,t);
98 echov(i,usd,t) = usd_v(i,t);

```

```

99 echov(i,usf,t) = usf_v(i,t);
100 echov(i,kor,t) = kor_v(i,t);
101 echov(i,row,t) = row_v(i,t);
102
103 display echov,echoq;
104
105 *          Calculate the price trajectories
106 Parameter ptraj(i,r,t)          Price trajectory
107           qtraj(i,r,t)          Quantity trajectory;
108
109 ptraj(i,r,t)$auv(i,r,"2012") = auv(i,r,t)/auv(i,r,"2012");
110 ptraj(i,r,t)$ (not ptraj(i,r,t)) = ptraj("OTH",r,t);
111
112 qtraj(i,r,t) = 1;
113 qtraj(i,usd,t)$usd_q(i,"2012") = usd_q(i,t)/usd_q(i,"2012");
114 qtraj(i,usf,t)$usf_q(i,"2012") = usf_q(i,t)/usf_q(i,"2012");
115 qtraj(i,kor,t)$kor_q(i,"2012") = kor_q(i,t)/kor_q(i,"2012");
116 qtraj(i,row,t)$row_q(i,"2012") = row_q(i,t)/row_q(i,"2012");
117
118 *Hardwire for Korea's entry into Utility segment in 2015
119 qtraj("UTL",kor,"2016") = kor_q("UTL","2016")/kor_q("UTL","2015");
120
121 display ptraj,qtraj;
122
123 *          First-order reference prices and quantities for 2012.
124 *          Consistent with Francois and Hall (1997) [COMPAS] we
125 *          choose units such that reference prices are one:
126
127 Parameters
128     x0(i,r)          reference quantities ($m),
129     p0(i,r) reference prices (one),
130     q0(i)             reference quantity ($m)
131     z0(i)  reference price index (one);
132
133 x0(i,usd) = usd_v(i,"2012")/1000;
134 x0(i,usf) = usf_v(i,"2012")/1000;
135 x0(i,kor) = kor_v(i,"2012")/1000;
136 x0(i,row) = row_v(i,"2012")/1000;
137 p0(i,r)   = 1;
138 q0(i)     = sum(r,x0(i,r));
139 z0(i)     = 1;
140
141 display x0,p0,q0,z0;
142
143 *          Elasticities
144 Parameters
145     eta          demand elasticity          /%eta%/,
146     sigTop       Top-level substitution elasticity between segments /%sigT%/
147     sig(i)       Armington elasticity of substitution,
148     mu(i,r)      supply elasticity          ;
149 sig("UTL") = %sig1%;

```

```

150 sig("OTH") = %sig2%;
151 mu(i,usd)   = %muusd%;
152 mu(i,usf)   = %muusf%;
153 mu(i,kor)   = %mukor%;
154 mu(i,row)   = %murow%;
155
156
157 *           Calibration parameters
158 Parameter
159     y0(t)           Benchmark total demand
160     theta(i,t)      Value share of segment i
161     ks0(i,r,t)      Constant in CE supply function
162     kd0(t)          Constant in CE aggregate demand function
163     alpha0(i,r)     CES (relative) distribution parameters
164     phi(i,t)        CES scale parameter
165     qref(i,t)       Reference quantity segment i
166     pref(i,t)       Reference price segment i
167 ;
168
169 y0(t)              = sum((i,r),x0(i,r)*p0(i,r));
170 ks0(i,r,t)         = x0(i,r)/(p0(i,r)**mu(i,r));
171 kd0(t)             = sum((i,r),x0(i,r)*p0(i,r));
172 alpha0(i,r)        = p0(i,r)*(x0(i,r)+1e-6)**(1/sig(i)) /
173                     sum(rr,p0(i,rr)*x0(i,rr)**(1/sig(i)));
174 phi(i,t)           = (sum(r, alpha0(i,r)**sig(i) *
175                       p0(i,r)**(1-sig(i))))**1/(1-sig(i));
176 theta(i,t)         = sum(r,x0(i,r)*p0(i,r))/sum((r,ii),x0(ii,r)*p0(ii,r));
177 qref(i,t)          = q0(i);
178 pref(i,t)          = z0(i);
179
180 Parameter
181     xbar(i,r,t)     import-volume restriction instrument;
182 xbar(i,r,t) = x0(i,r);
183
184 Positive Variables
185     Y(t)            Top-level demand index
186     PY(t)           Top-level price index
187     Q(i,t)          Quantity demanded by segment
188     Z(i,t)          True price index on Armington aggregate (US price index)
189     P(i,r,t)        Price of goods in segment i source type r
190     X(i,r,t)        Quantity of goods in segment i source type r
191     tau1(i,r,t)     Import restriction instrument (increased trade cost)
192     tau2(i,r,t)     Import restriction instrument (decreased trade cost)
193
194 *           time dependent calibration instruments
195     alpha(i,r,t)    Partial productivity parameter (1 in 2012);
196
197 Equations
198     Demand(t)       Aggregate demand
199     PY_def(t)       Segment aggregation (dual representation)
200     SegMkt(i,t)     Market clearance by segment,

```

```

201      Arm(i,t)          Armington aggregation (dual representation),
202      Mkt(i,r,t)         Market clearance for each imported and domestic variety,
203      Sup(i,r,t)         Supply schedule for each imported and domestic variety
204      QConst1(i,r,t)     Artificial external restriction for import reductions
205      QConst2(i,r,t)     Artificial external restriction for import expansion;
206
207 Demand(t)..
208      sum((i,r),x0(i,r)*p0(i,r))*Y(t) - kd0(t) * PY(t)**eta =g= 0;
209
210 PY_def(t)..
211      (sum(i,theta(i,t)*(Z(i,t)/pref(i,t))**(1-sigTop)))*(1/(1-sigTop))
212      - PY(t) =g= 0;
213
214 SegMkt(i,t)..
215      Q(i,t) - qref(i,t)*Y(t)*(pref(i,t)*PY(t)/Z(i,t))**sigTop =g= 0;
216
217 Arm(i,t)..
218      (1/phi(i,t))*
219      (sum(r,$ks0(i,r,t), (alpha(i,r,t)*alpha0(i,r))**sig(i) *
220      (P(i,r,t)*(tau1(i,r,t)/tau2(i,r,t))**(1-sig(i))))*(1/(1-sig(i))))
221      - Z(i,t) =g= 0;
222
223 Mkt(i,r,t)$ks0(i,r,t)..
224      X(i,r,t)
225      - Q(i,t)/phi(i,t) *
226      ((alpha(i,r,t)*alpha0(i,r))*phi(i,t)*Z(i,t)/
227      (P(i,r,t)*(tau1(i,r,t)/tau2(i,r,t))**sig(i)
228      =g= 0;
229
230 Sup(i,r,t)$ks0(i,r,t)..
231      ks0(i,r,t)*P(i,r,t)**mu(i,r) - X(i,r,t) =g= 0;
232
233 QConst1(i,r,t)$ks0(i,r,t)..
234      xbar(i,r,t) - X(i,r,t) =g= 0;
235 QConst2(i,r,t)$ks0(i,r,t)..
236      -xbar(i,r,t) + X(i,r,t) =g= 0;
237
238 Model GAMS_COMPAS /
239 *      Basic COMPAS equations with the extension of multiple segments
240      Demand.PY,PY_def.Y,SegMkt.Z,Arm.Q,Mkt.P,Sup.X,
241 *      plus the instruments for experiments
242      QConst1.tau1
243      QConst2.tau2/;
244
245 *      Set all values to initial (2012) equilibrium
246 Y.l(t)      = 1;
247 PY.l(t)     = 1;
248 Q.l(i,t)    = q0(i);
249 Z.l(i,t)    = z0(i);
250 P.l(i,r,t)  = p0(i,r);
251 X.l(i,r,t)  = x0(i,r);

```

```

252
253 *      All instruments that are declared as variables are fixed
254 *      for the initial 2012 replication
255 tau1.fx(i,r,t)      = 1;
256 tau2.fx(i,r,t)      = 1;
257 alpha.fx(i,r,t) = 1;
258
259 gams_compas.savepoint=1;
260 gams_compas.iterlim = 0;
261 Solve gams_compas using mcp;
262 Abort$(gams_compas.objval gt 1e-5) "The model fails the 2012 replication";
263 gams_compas.savepoint=0;
264
265
266 *      First set of experiments: consider 2012 as a fixed benchmark
267 *      Setup some reports
268 Parameter
269     rev(*,*,r,t)      revenue ($1000),
270     qnt(*,*,r,t)      quantity (kW),
271     prc(*,*,r,t)      price ($ per kW)
272     deltrev12(*,*,r,t) change in (net of tau) revenue relative to 2012 ($1000)
273     deltrev(*,*,r,t)  change in (net of tau) revenue relative to t ($1000);
274
275 *      these need initialized
276 rev("bmk2012",i,r,t) = echov(i,r,"2012");
277 rev("bmk",i,r,t)     = echov(i,r,t);
278
279 $onechov >rpt2.gms
280 rev("%1",i,r,t) = P.l(i,r,t)*X.l(i,r,t)*1000;
281 rev("%1","Total",r,t) = sum(i,rev("%1",i,r,t));
282 prc("%1",i,r,t) = P.l(i,r,t)*auv(i,r,"2012");
283 prc("%1",i,r,t)$ (not prc("%1",i,r,t)) = 1;
284 qnt("%1",i,r,t) = rev("%1",i,r,t)*1000/prc("%1",i,r,t);
285 qnt("%1","Total",r,t) = sum(i,qnt("%1",i,r,t));
286 deltrev12("%1",i,r,t) = rev("%1",i,r,t) - rev("bmk2012",i,r,t);
287 deltrev("%1",i,r,t)   = rev("%1",i,r,t) - rev("bmk",i,r,t);
288 deltrev("%1","Total",r,t) = sum(i,deltrev("%1",i,r,t));
289 $offecho
290
291 $batinclude rpt2.gms bmk2012
292 $batinclude rpt2.gms bmk2012
293
294
295 *~~~~~
296 *      Now find the relative and absolute calibration adjustments
297 *      for the calibration over time
298
299 *      Reset everything to the point before the counterfactuals
300 xbar(i,r,t) = x0(i,r);
301 Execute_loadpoint 'gams_compas_p';
302 tau1.fx(i,r,t)      = 1;

```

```

303 tau2.fx(i,r,t) = 1;
304 alpha.fx(i,r,t) = 1;
305
306 *           Fix endogenous variables
307 X.fx(i,r,t)   = x0(i,r)*qtraj(i,r,t);
308 P.fx(i,r,t)   = ptraj(i,r,t);
309 Z.fx(i,t)     = 1;
310 Q.fx(i,t)     = sum(r,P.l(i,r,t)*X.l(i,r,t)/Z.l(i,t));
311 PY.fx(t)      = 1;
312 Y.fx(t)       = sum(i,Q.l(i,t))/sum(i,Q.l(i,"2012"));
313
314 *           Set the time dependent supply and demand constants
315 ks0(i,r,t) = X.l(i,r,t)/P.l(i,r,t)**mu(i,r);
316 kd0(t)     = y0(t)*Y.l(t)/PY.l(t)**eta;
317 y0(t)      = sum((i,r),P.l(i,r,t)*X.l(i,r,t));
318 theta(i,t)= Q.l(i,t)*Z.l(i,t)/sum(ii,Q.l(ii,t)*Z.l(ii,t));
319 qref(i,t) = Q.l(i,t)/Y.l(t);
320
321 Model calib /Mkt.alpha/;
322
323 *           Solve for the implied alpha
324 alpha.lo(i,r,t) = 1e-2; alpha.up(i,r,t) = +inf;
325 alpha.fx(i,r,t)$(not ks0(i,r,t)) = 0;
326
327 calib.iterlim = 10000;
328 Solve calib using mcp
329 Abort$(calib.objval gt 1e-6) "The Calibration model failed";
330
331 *           Renormalize the alphas as "relative" productivity parameters
332 alpha.fx(i,r,t) = alpha.l(i,r,t)/sum(rr,alpha.l(i,rr,t)*alpha0(i,rr));
333 phi(i,t) = (1/Z.l(i,t))*(sum(r$ks0(i,r,t),
334                               (alpha.l(i,r,t)*alpha0(i,r))**sig(i) *
335                               P.l(i,r,t)**(1-sig(i))))*(1/(1-sig(i)));
336
337 *           Benchmark replication across all time periods
338 Y.lo(t)      =0; Y.up(t)      = +inf;
339 PY.lo(t)     =0; PY.up(t)     = +inf;
340 Q.lo(i,t)    =0; Q.up(i,t)    = +inf;
341 Z.lo(i,t)    =0; Z.up(i,t)    = +inf;
342 P.lo(i,r,t)  =0; P.up(i,r,t)  = +inf;
343 X.lo(i,r,t)  =0; X.up(i,r,t)  = +inf;
344 xbar(i,r,t)  =X.l(i,r,t);
345
346 gams_compas.savepoint=1;
347 gams_compas.iterlim=0;
348 Solve gams_compas using mcp;
349 Abort$(gams_compas.objval gt 1e-5) "Failure to replicate yearly equilibrium";
350 gams_compas.savepoint=0;
351
352 $batinclude rpt2.gms bmk
353

```

```

354 * restrict all imports to their previous year's value
355
356 xbar(i,r,t)$(not usa(r) and not t0(t)) = xbar(i,r,t-1);
357 *           We have to define a positive cap for Korea in 2015
358 *           (as there are zero UTL imports in 2014) let's say $10k
359 xbar(i,r,t)$(not xbar(i,r,t) and ks0(i,r,t)) = 0.001;
360 tau1.up(i,r,t)$(not usa(r) and not t0(t)) = +inf;
361 tau1.lo(i,r,t)$(not usa(r) and not t0(t)) = 1;
362
363 gams_compas.iterlim=10000;
364 Solve gams_compas using mcp;
365 Abort$(gams_compas.objval gt 1e-5) "the model fails to solve";
366
367 $batinclude rpt2.gms allyryr
368 display deltrev;
369
370 tau1.fx(i,row,t) = 1;
371
372 gams_compas.iterlim=10000;
373 Solve gams_compas using mcp;
374 Abort$(gams_compas.objval gt 1e-5) "the model fails to solve";
375
376 $batinclude rpt2.gms koryryr
377
378 tau1.fx(i,kor,t) = 1;
379 tau1.up(i,row,t)$(not t0(t)) = +inf;
380 tau1.lo(i,row,t)$(not t0(t)) = 1;
381
382 gams_compas.iterlim=10000;
383 Solve gams_compas using mcp;
384 Abort$(gams_compas.objval gt 1e-5) "the model fails to solve";
385
386 $batinclude rpt2.gms rowryryr
387 display deltrev;
388
389 *           Dump the essential data presented in Tables 6 or 7
390 Parameter      T_yoy      table 6 or 7 depending on sig2 setting;
391 T_yoy("all_importers",t)   = -deltrev("allyryr","total","usd",t);
392 T_yoy("Korea (KOR)",t)     = -deltrev("koryryr","total","usd",t);
393 T_yoy("Rest-of-World (ROW)",t)= -deltrev("rowryryr","total","usd",t);
394 T_yoy("all_importers","total") =sum(t, -deltrev("allyryr","total","usd",t));
395 T_yoy("Korea (KOR)","total")   =sum(t, -deltrev("koryryr","total","usd",t));
396 T_yoy("Rest-of-World (ROW)","total")=sum(t, -deltrev("rowryryr","total","usd",t));
397
398 option T_yoy:0;
399 display T_yoy;
400
401 Parameter      ratio;
402 ratio = t_yoy("Korea (KOR)","2016")/T_yoy("Rest-of-World (ROW)","2016");
403
404 file segout /segout.txt/; segout.ap=1;

```

```
405 put segout '%eta%', ' %sigT%', ' %sig1%', ' %sig2%',  
406 ' %muusd%', ' %muusf%', ' %mukor%', ' %murow%', ratio;  
407  
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Appendix B: Curriculum Vitae

Edward J. Balistreri

Curriculum Vitae

July 2017

CONTACT INFORMATION	Edward J. Balistreri	<i>voice:</i> +1 303 384 2156
	Department of Economics	<i>e-mail:</i> ebalistr@iastate.edu
	Iowa State University	<i>web:</i> inside.mines.edu/~ebalistr
	518 Farm House LN, Heady Hall	<i>google scholar:</i> Edward J. Balistreri
	Ames, Iowa 50011	
EDUCATION	Ph.D., Economics, University of Colorado (1995)	
	Dissertation: <i>Preference Revelation and the Endogenous Trade Policy Model: Empirical and Experimental Evidence for Stolper-Samuelson Welfare Effects</i>	
	(Supervisor: William H. Kaempfer)	
	Fields: <i>International Economics</i> and <i>Public Economics</i>	
	M.A., Economics, University of Colorado (1993)	
	B.A., Economics, Arizona State University (1989)	
EXPERIENCE	Iowa State University	
	<i>Associate Professor</i> , Department of Economics	2017–
	Colorado School of Mines	
	<i>Associate Professor</i> , Division of Economics and Business	2010–2017
	<i>Program Director</i> , Mineral and Energy Economics	2013–2015
	<i>Assistant Professor</i> , Division of Economics and Business	2004–2010
	United States International Trade Commission	
	<i>Economist</i> (GS-14), Office of Economics, Research Division	2001–2004
	Charles River Associates, Inc.	
	<i>Senior Associate</i> , Washington DC	1996–2001
INVITED APPOINTMENTS AND AWARDS	University of Colorado	
	<i>Research Associate/Assistant</i> , The Center for Economic Analysis, and	
	The Center for Research on Judgment and Policy	1993–1996
	<i>Teaching Assistant</i> , Department of Economics	1990–1993
	United States Environmental Protection Agency	
	<i>Science Advisory Board</i> , Economy-wide Modeling Panel	2015–2017
	<i>Advances in Applied General Equilibrium Modeling</i> (Springer)	
	<i>Editorial Board</i>	2015–
	<i>Journal of Environmental Economics and Management</i> (Elsevier)	
	<i>Editorial Council</i>	2014–
	Colorado School of Mines, Division of Economics and Business	
	<i>Excellence in Teaching Award</i> , MEE Graduate Programs	AY 2013-2014
	National Center for Atmospheric Research (NCAR)	
	<i>Affiliate Scientist</i> , Integrated Assessment Modeling Group	2012–
	United States Environmental Protection Agency	
	<i>Stakeholder Panel for Managing Commodity-grade Mercury</i>	2007

PUBLICATIONS
AND RESEARCH

Journal Articles

Balistreri, Edward J., Maryla Maliszewska, Israel Osorio-Rodarte, David G. Tarr, and Hidemichi Yonezawa (forthcoming) ‘Poverty, welfare and income distribution implications of reducing trade costs through deep integration in Eastern and Southern Africa,’ *Journal of African Economies*

Balistreri, Edward J., Christoph Böhringer and Thomas F. Rutherford (forthcoming) ‘Carbon policy and the structure of global trade,’ *The World Economy*

Balistreri, Edward J., Zoryana Olekseyuk and David Tarr (forthcoming) ‘Privatization and the Unusual Case of Belarusian Accession to the WTO,’ *The World Economy*

Olekseyuk, Zoryana and Edward J. Balistreri (forthcoming) ‘Trade liberalization gains under different trade theories: A case study for Ukraine,’ *Empirica*

Ren, Xiaolin, Peter Lawrence, Matthias Weitzel, Brian O’Neill, Sam Levis, Prasanth Meiyappan, Edward J. Balistreri and Mike Dalton (forthcoming) ‘Avoided economic impacts of climate change on agriculture: integrating a Land Surface Model (CLM) with an Economic Model (iPETS),’ *Climatic Change*

Balistreri, Edward J., Jesper Jensen, and David Tarr (2015) ‘What determines whether preferential liberalization of barriers against foreign investors in services are beneficial or immiserising?: Application to the case of Kenya,’ *Economics: The Open-Access, Open-Assessment E-Journal*, 9(2015-42), 1–134

Balistreri, Edward J., David G. Tarr, and Hidemichi Yonezawa (2015) ‘Deep Integration in Eastern and Southern Africa: What are the Stakes?,’ *Journal of African Economies*, 24(5), 677–706

Böhringer, Christoph, Edward J. Balistreri, and Thomas F. Rutherford (2012) ‘The role of border carbon adjustment in unilateral climate policy: Overview of an Energy Modeling Forum study (EMF 29),’ *Energy Economics* 34(S2), S97–S110

Balistreri, Edward J. and Thomas F. Rutherford (2012) ‘Subglobal carbon policy and the competitive selection of heterogeneous firms,’ *Energy Economics* 34(S2), S190–S197

Balistreri, Edward J., Russell H. Hillberry, and Thomas F. Rutherford (2011) ‘Structural estimation and solution of international trade models with heterogeneous firms,’ *Journal of International Economics* 83(2), 95–108 (lead article)

Reprinted in Kym Anderson (ed.) *Measuring WTO’s Contribution to Global Economic Growth* (2014) Edward Elgar Publishing Ltd.: Cheltenham (Volume 21 in the series *Critical Perspectives on the Global Trading System and the WTO*)

- Vásquez Cordano, Arturo L., and Edward J. Balistreri (2010) ‘The marginal cost of public funds of mineral and energy taxes in Peru,’ *Resources Policy* 35(4), 257–264
- Balistreri, Edward J., Russell H. Hillberry, and Thomas F. Rutherford (2010) ‘Trade and welfare: Does industrial organization matter?’ *Economics Letters* 109(2), 85–87
- Balistreri, Edward J., Ayed Al-Qahtani, and Carol A. Dahl (2010) ‘Oil and petroleum product Armington elasticities: A new-geography-of-trade approach to estimation,’ *The Energy Journal* 31(3), 165–177
- Balistreri, Edward J., and Christopher M. Worley (2009) ‘Mercury: the good, the bad, and the export ban,’ *Resources Policy* 34(4), 195–204
- Balistreri, Edward J., Thomas F. Rutherford, and David G. Tarr (2009) ‘Modeling services liberalization: The case of Kenya,’ *Economic Modelling* 26(3), 668–679
- Balistreri, Edward J., and James R. Markusen (2009) ‘Sub-national differentiation and the role of the firm in optimal international pricing,’ *Economic Modelling* 26(1), 47–62
- Balistreri, Edward J., and Russell H. Hillberry (2008) ‘The gravity model: An illustration of structural estimation as calibration,’ *Economic Inquiry* 46(4), 511–527
- Balistreri, Edward J., and Russell H. Hillberry (2007) ‘Structural estimation and the border puzzle,’ *Journal of International Economics* 72(2), 451–463
- Al-Qahtani, Ayed, Edward J. Balistreri, and Carol A. Dahl (2007) ‘Estimating the U.S. Dollar Depreciation Effect on Oil Prices,’ *Journal of Energy and Development* 33(1), 49–55
- Balistreri, Edward J., and Russell H. Hillberry (2006) ‘Trade frictions and welfare in the gravity model: how much of the iceberg melts?’ *Canadian Journal of Economics* 39(1), 247–265
- Andriamananjara, Soamiely, Edward J. Balistreri, and Martin T. Ross (2006) ‘State-level equity and the demise of the agreement on textiles and clothing,’ *The North American Journal of Economics and Finance* 17(1), 17–33
- Hillberry, Russell H., Michael A. Anderson, Edward J. Balistreri, and Alan K. Fox (2005) ‘Taste parameters as model residuals: Assessing the ‘fit’ of an Armington trade model,’ *Review of International Economics* 13(5), 973–984
- Balistreri, Edward J., Christine A. McDaniel, and Eina Vivian Wong (2003) ‘An estimation of US industry-level capital-labor substitution elasticities: support for Cobb-Douglas,’ *The North American Journal of Economics and Finance* 14(3), 343–356

McDaniel, Christine A., and Edward J. Balistreri (2003) ‘A review of Armington trade substitution elasticities,’ *Économie Internationale* 94-95, 301–314

Joint publication: (2003) *Integration and Trade* N° 18, Vol. 7, 161–173

Balistreri, Edward J. (2002) ‘Operationalizing equilibrium unemployment: A general equilibrium external economies approach,’ *Journal of Economic Dynamics and Control* 26(3), 347–374

Balistreri, Edward, Gary McClelland, Gregory Poe, and William Schulze (2001) ‘Can hypothetical questions reveal true values? a laboratory comparison of dichotomous choice and open-ended contingent values with auction values,’ *Environmental and Resource Economics* 18(3), 275–292

Yohe, Gary, W. David Montgomery, and Ed Balistreri (2000) ‘Equity and the Kyoto protocol: measuring the distributional effects of alternative emissions trading regimes,’ *Global Environmental Change* 10(2), 121–132

Balistreri, Edward J. (1997) ‘The performance of the Heckscher-Ohlin-Vanek model in predicting endogenous policy forces at the individual level,’ *Canadian Journal of Economics* 30(1), 1–17 (lead article)

Book Chapters

Sue Wing, Ian and Edward J. Balistreri (forthcoming) ‘Computable General Equilibrium Models for Policy Evaluation and Economic Consequence Analysis,’ *Oxford University Press Handbook on Computational Economics and Finance*

Balistreri, Edward J. and David G. Tarr (2014) ‘Introduction and Key Tables from: Services Liberalization in Preferential Trade Arrangements: The Case of Kenya,’ in David G. Tarr’s *Applied Trade Policy Modeling in 16 Countries: Insights and Impacts from World Bank CGE Based Projects*, World Scientific, 439–451

Balistreri, Edward J. and Thomas F. Rutherford (2013) ‘Computing General Equilibrium Theories of Monopolistic Competition and Heterogeneous Firms,’ in Peter B. Dixon and Dale W. Jorgenson (Eds.) *Handbook of Computable General Equilibrium Modeling*, North Holland, Elsevier B.V., 1513–1570

Working Papers

‘Optimal environmental border adjustments under the General Agreement on Tariffs and Trade,’ with Daniel T. Kaffine and Hidemichi Yonezawa (2014) Colorado School of Mines, Division of Economics and Business, *Working Paper 2014-03*, February

‘The suboptimal nature of applying Pigouvian rates as border adjustments,’ with Hidemichi Yonezawa and Daniel T. Kaffine (2012) Colorado School of Mines, Division of Economics and Business, *Working Paper 2012-02*, June

Technical Reports **[Role]**

Balistreri, Edward J., Maryla Maliszewska, Israel Osorio-Rodarte, David G. Tarr, and Hidemichi Yonezawa (2016) *Poverty and Shared Prosperity Implications of Deep Integration in Eastern and Southern Africa*, World Bank Policy Research Working Papers, WPS 7660, research partially funded by the World Bank (PSIA TF TF018287) and the Government of the Netherlands under the Bank-Netherlands partnership program (TF012466), May 2016. **[Coauthor]**

Ecoplan (2015) *Volkswirtschaftliche Auswirkungen eines Wegfalls der Bilateralen I: Analyse mit einem Mehrländergleichgewichtsmodell*, (translation: Economic ramifications of a discontinuation of the Bilateral I [agreement]: analysis with a multi-country equilibrium model), submitted on behalf of the [Swiss] Secretariat of State for the economy, 12 November 2015, Project lead André Müller of Ecoplan, Bern. **[Model Development]**

Balistreri, Edward J., David G. Tarr, and Hidemichi Yonezawa (2014) *Reducing trade costs in East Africa: deep regional integration and multilateral action*, Policy Research Working Paper: 7049 (WPS7049), The World Bank, Development Research Group, Trade and International Integration Team, September 2014. **[Coauthor]**

Balistreri, Edward J., and David G. Tarr (2011) *Services Liberalization in Preferential Trade Arrangements: The case of Kenya*, Policy Research Working Paper: 5552 (WPS5552), The World Bank, Development Research Group, Trade and Integration Team, January 2011. **[Coauthor]**

Balistreri, Edward J., Thomas F. Rutherford and David G. Tarr (2008) *Modeling Services Liberalization: The case of Kenya*, Policy Research Working Paper: 4544 (WPS4544), The World Bank, Development Research Group, Trade Team, March 2008. **[Coauthor]**

Balistreri, Edward J., and James R. Markusen (2005) *National and Sub-national Differentiation in General Equilibrium Policy Simulation Models*, Division of Economics and Business, Colorado School of Mines, project sponsored by the United States International Trade Commission (ITC-PO-05-0035: \$38,508, May–August 2005). **[Principal Investigator]**

U.S.-Morocco Free Trade Agreement: Potential Economywide and Selected Sectoral Effects, United States International Trade Commission, Investigation TA-2104-14, August 2004. **[Coauthor]**

U.S. Free Trade Agreement with Central America and the Dominican Republic: Potential Economywide and Selected Sectoral Effects, United States International Trade Commission, Investigation TA-2104-13, June 2004. **[Coauthor]**

U.S.-Australia Free Trade Agreement: Potential Economywide and Selected Sectoral Effects, United States International Trade Commission, Investigation TA-2104-11, May 2004. **[Coauthor]**

U.S.-Andean Countries Free-Trade Agreement: Advice Concerning the Probable Economic Effects, United States International Trade Commission, Investigation TA-131-28 and TA-2104-8, April 2004. [**Numeric simulations only**]

U.S.-Panama Free-Trade Agreement: Advice Concerning the Probable Economic Effects, United States International Trade Commission, Investigation TA-131-27 and TA-2104-7, April 2004. [**Numeric simulations only**]

U.S.-Bahrain Free-Trade Agreement: Advice Concerning the Probable Economic Effects, United States International Trade Commission, Investigation TA-131-26 and TA-2104-6, December 2003. [**Coauthor**]

U.S.-Dominican Republic Free-Trade Agreement: Advice Concerning the Probable Economic Effects, United States International Trade Commission, Investigation TA-131-25 and TA-2104-5, December 2003. [**Numeric simulations only**]

Steel-Consuming Industries: Competitive Conditions with Respect to Steel Safeguard Measures, United States International Trade Commission, Publication 3632, September 2003. [**Coauthor**]

The Impact of Trade Agreements: Effects of the Tokyo Round, U.S.-Israel FTA, U.S.-Canada FTA, NAFTA, and the Uruguay Round on the U.S. Economy, United States International Trade Commission, Publication 3621, August 2003. [**Coauthor**]

U.S.-South African Customs Union Free-Trade Agreement: Advice Concerning the Probable Economic Effects, United States International Trade Commission, Investigation TA-131-23 and TA-2104-3, April 2003. [**Coauthor**]

Oil and Gas Field Services: Impediments to Trade and Prospects for Liberalization, United States International Trade Commission, Publication 3582, March 2003. [**Coauthor and Reviewer**]

U.S.-Chile Free-Trade Agreement: Advice Concerning the Probable Economic Effects, United States International Trade Commission, Investigation 332-442, Fall 2002. [**Primary Reviewer**]

The Economic Effects of Significant U.S. Import Restraints: Third Update 2002, United States International Trade Commission, Publication 3519, June 2002. [**Coauthor**]

A General Equilibrium Assessment of OTAG Regulations: State and Regional Impacts, Charles River Associates, Inc., report prepared for Southern Company Services, February 1998. [**Coauthor**]

Economic Implications of the Adoption of Limits on Carbon Emissions from Industrialized Countries, Charles River Associates, Inc., report prepared for the American Automobile Manufacturers Association, November 1997. [**Coauthor**]

An Evaluation of Public Preferences for Superfund Site Cleanup, Volume 1: A Preliminary Assessment, The Center for Economic Analysis and The Center for Research on Judgment and Policy, University of Colorado—Boulder, report submitted to the USEPA, March 1995.[Coauthor]

An Evaluation of Public Preferences for Superfund Site Cleanup, Volume 2: A Pilot Study, The Center for Economic Analysis and The Center for Research on Judgment and Policy, University of Colorado—Boulder, report submitted to the USEPA, March 1994.[Coauthor]

McClelland, Gary, William Schulze, and Edward Balistreri (1994) *An Examination of Performance Testing Requirements for Contingent Valuation*, The Center for Economic Analysis and The Center for Research on Judgment and Policy, University of Colorado—Boulder, report reproduced in its entirety as an appendix to *Comments on the Proposed NOAA/DOI Regulations on Natural Resource Damage Assessment*, USEPA, Washington DC, October 1994. [Coauthor]

Conference and Other Publications

‘Introduction to the EMF 29 special issue on the role of border carbon adjustment in unilateral climate policy’ with Christoph Böhringer, Thomas F. Rutherford and John Weyant (2012) *Energy Economics* 34(S2), S95–S96.

‘Large-scale CGE modeling at the United States International Trade Commission’ with others (2002), printed in the proceedings of the Fifth Annual Conference on Global Economic Analysis, June 5-7, Taipei, Taiwan, Vol.2, pp. O1-O18.

‘USAGE-ITC: data and parameters,’ with others (2002), printed in the proceedings of the Fifth Annual Conference on Global Economic Analysis, June 5-7, Taipei, Taiwan, Vol.2, pp. O44-O66.

‘Dynamic General Equilibrium Analysis at the State Level: Assessing the economic implications of the Kyoto Protocol,’ with Thomas F. Rutherford (2001), printed in the proceedings of the Fourth Annual Conference on Global Economic Analysis, June 27-29, Purdue University, West Lafayette, IN, Vol.2, Session 1, Regional Economics I.

Book Reviews

Maria Eugenia Ibararán and Roy Boyd (2006) *Hacia El Futuro: Energy and the Environment in 21st Century Mexico*, Springer, Review in *The Energy Journal* 29(1) 173–175, January 2008.

REFEREING
SERVICE

American Economic Review, American Journal of Agricultural Economics, Canadian Journal of Economics, China Economic Review, Economic Modelling, Economics and Politics, Économie Internationale, Energy Economics, The Energy

Journal, Energy Studies Review, Environmental and Resource Economics, Integration and Trade, International Economic Journal, Journal of the Association of Environmental and Resource Economists, Journal of Environmental Economics and Management, Journal of International Economics, Quarterly Journal of Economics, Resources and Energy Economics, Resources Policy, Review of International Economics, World Economy, The World Bank Policy Research Working Paper Series; and abstract reviews for the 2006, 2007, 2008, 2011 and 2016 GTAP conferences and the 2016 AERE conference.

TEACHING AND
UNIVERSITY
SERVICE

PhD Advisees:

Khalid Aljihrish (2015) *International Market Power in Oil and Responses to Climate Policy*, CSM Division of Econ&Bus, summer 2015

Yahya Anouti (2015) *Resource Linkages and Sustainable Development*, CSM Division of Econ&Bus, spring 2015, coadvisor Carol Dahl

Hidemichi Yonezawa (2012) *Theoretic and Empirical Issues Related to Border Carbon Adjustments*, CSM Division of Econ&Bus, fall 2012

Lauren M. Davis (2009) *Modeling the State-level Impacts of Carbon Policy: The Case of Colorado*, CSM Division of Econ&Bus, fall 2009

Ayed Al-Qahtani (2008) *A Model for the Global Oil Market: Optimal Oil Production Levels for Saudi Arabia*, CSM Division of Econ&Bus, fall 2008, coadvisor Carol Dahl

Undergraduate and Combined Courses

Public Economics (CSM) EBGN 443

International Economics/Trade (CSM) EBGN 441/541

Advanced topics in Microeconomics (CSM) EBGN 404/598

Summer Field Session (CSM) EBGN 402

Business Strategy (CSM) EBGN 315

Graduate Courses

Research Methodology (CSM: PhD Core) EBGN 695

Advanced Microeconomics (CSM: PhD Core) EBGN 611

Environmental Economics (CSM) EBGN 570

Economics and Decision Making (CSM: ETM) EBGN 515

Microeconomics (CSM: MS/PhD Core) EBGN 511

Short Courses

Ruhr Graduate Summer School 2016: Trade and Climate Policy Analysis with GAMS and MPSGE, with Christoph Böhringer and Volker Clausen, University of Duisburg-Essen, Germany, September 19 - September 23, 2016

Ruhr Graduate Summer School 2015: Trade and Climate Policy Analysis with GAMS and MPSGE, with Christoph Böhringer and Volker Clausen, University of Duisburg-Essen, Germany, September 28 - October 2, 2015

Ruhr Graduate Summer School 2014: Trade and Climate Policy Analysis with GAMS and MPSGE, with Christoph Böhringer and Volker Clausen, University of Duisburg-Essen, Germany, September 29 - October 3, 2014

Ruhr Graduate Summer School 2013: Trade and Climate Policy Analysis with GAMS and MPSGE, with Christoph Böhringer and Volker Clausen, University of Duisburg-Essen, Germany, August 5-9, 2013

13th Workshop on Economic Modeling (WEM): Computable General Equilibrium Analysis Using GTAPinGAMS and New Trade Theory, with Christoph Böhringer and Casiano Manrique, Universidad de Las Palmas de Gran Canaria, March 11-15, 2013

12th Workshop on Economic Modeling (WEM): Applied General Equilibrium Analysis of Trade and Climate Policies using GAMS and GTAP, with Christoph Böhringer and Casiano Manrique, Universidad de Las Palmas de Gran Canaria, March 12-16, 2012

Introduction to Computable General Equilibrium Modeling with GAMS and MPSGE, with James R. Markusen, University of Melbourne, July 11-15, 2011

Thesis Committees	(Degree, Institution, Completion Date)
Maxwell Brown	(PhD, CSM Division of Econ&Bus, spring 2017)
Nan Xu	(PhD, CU–Boulder Econ Dept., spring 2017)
Jacquelyn Pless	(PhD, CSM Division of Econ&Bus, spring 2016)
Fadli Rahman	(PhD, CSM Division of Econ&Bus, spring 2016)
Zoryana Olekseyuk	(PhD, Uni. Duisburg–Essen, Econ, fall 2015)
Karri Hickenbottom	(PhD, CSM Civil&Env. Engr., summer 2015)
Yibei Liu	(PhD, CU–Boulder Econ Dept., summer 2014)
Greg Steeger	(PhD, CSM Division of Econ&Bus, spring 2014)
Brian Batson	(PhD, CSM Division of Econ&Bus, spring 2014)
Peifang Yang	(PhD, CSM Division of Econ&Bus, spring 2014)
Kyungsoo Oh	(PhD, CU–Boulder Econ Dept., spring 2013)
Kaylee Acuff	(PhD, CSM Division of Econ&Bus, spring 2013)
Megumi Nishimura	(PhD, CU–Boulder Econ Dept., summer 2012)
Christopher M. Worley	(PhD, CSM Division of Econ&Bus, spring 2011)
Bridget Strand	(PhD, CU–Boulder Econ Dept., fall 2010)
Daniel Jerrett	(PhD, CSM Division of Econ&Bus, spring 2010)
Emily Newes	(MS, CSM Division of Econ&Bus, summer 2009)
Yen-Heng Chen	(PhD, CU–Boulder Econ Dept., fall 2008)
Leila Dagher	(PhD, CSM Division of Econ&Bus, fall 2008)
Alex Schroeder	(MS, CSM Division of Econ&Bus, spring 2007)
Mei Yuan	(PhD, CU–Boulder Econ Dept., spring 2007)
Lei Yang	(PhD, CU–Boulder Econ Dept., spring 2007)
Roberto F. Aguilera	(PhD, CSM Division of Econ&Bus, fall 2006)
J. Tyler Hodge	(PhD, CSM Division of Econ&Bus, fall 2006)
Claudio Valencia	(PhD, CSM Division of Econ&Bus, spring 2005)

Other Faculty Service

The Research Council of the Colorado School of Mines	2007–2011
The Undergraduate Council of the Colorado School of Mines	2004–2007

OTHER PROFESSIONAL ACTIVITIES	Recent Presentations	
	GTAP Conference, West Lafayette IN	June 2017
	Iowa State University, Ames IA	Jan. 2017
	University of Idaho, Moscow ID	Jan. 2017
	Purdue University, Ag. Econ. Dept., West Lafayette IN	Dec. 2016
	Purdue University, GTAP Brownbag, West Lafayette IN	Dec. 2016
	NCAR, Integrated Assessment Group, Boulder CO	Sept. 2016
	Western Economic Association International, Portland OR	June 2016
	GTAP Conference, Washington DC	June 2016
	AERE Summer Conference, Breckenridge CO	June 2016
	Payne Institute Meeting, Denver CO	Feb. 2016
	The World Bank, Washington DC	Oct. 2015
	NCAR, Integrated Assessment Group, Boulder CO	Sept. 2015
	University of Idaho and Wash. State University, Moscow ID	Oct. 2014
	NCAR, Integrated Assessment Group, Boulder CO	July 2014
	Western Economic Association International, Denver CO	June 2014
	The World Bank, Washington DC	April 2014
	NCAR, Integrated Assessment Group, Boulder CO	Aug. 2013

Significant Consulting Projects

How Large are the Welfare Impacts of the Heterogeneous Firms Model: Results from an Assessment of the Trans-Pacific Partnership and from Stylized Models (2016-2017), client: The World Bank.

Poverty and Shared Prosperity Implications of Deep Integration in Eastern and Southern Africa (2015), client: The World Bank.

Policy reforms in Belarus: empirical model development, including imperfect-competition and foreign direct investment (2014), client: The World Bank.

Reducing trade costs in East Africa: a GTAP based multiregion approach with imperfect-competition and foreign direct investment (2012-2014), client: The World Bank.

Policy reforms in Malaysia: empirical model development, including imperfect-competition and foreign direct investment (2012), client: The World Bank.

Foreign direct investment in services: model development (2011), client: The World Bank.

Welfare analysis of services liberalization in Kenya, including imperfect-competition and heterogeneous-firms formulations (2008-2010), client: The World Bank.

State-level Impact Assessment Model (SIAM), which analyzed climate-change policy, development and maintenance for Charles River Associates (1998-2001), client: Electric Power Research Institute.

Analyzed the distributional impacts of alternative carbon-policy revenue recycling mechanisms (2000), client: Electric Power Research Institute.

Analyzed the role of the Diesel internal combustion engine in the U.S. economy (2000), client: Diesel Technology Forum.

Contributed analysis for regulatory filings in a major electric utility merger (1998-1999).

Developed and implemented a merger simulation model to analyze the price impacts of a proposed merger between two major suppliers of a retail food product, for potential use in filings and litigation (1998).

Explored the role of alternative unemployment formulations and their practicality for implementation in dynamic general-equilibrium models of climate-change policy (1998), client: Electric Power Research Institute.

Applied a merger simulation model to analyze impacts in the telecommunications industry (1998).

Analyzed the impacts of proposed regulations to curb NOx emissions (state implementation plans or SIPs) in the OTAG regions (1998), client: Southern Company Services.

REFERENCES Available upon request