Trade Models and Macroeconomics

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Abstract

This paper discusses some macro links that are missing from trade models. A multicountry macroeconometric model is used to analyze the effects on the United States of increased import competition from China, an experiment that is common in the recent trade literature. In the macro story a fall in Chinese export prices is stimulative. Domestic prices fall, which increases real wage rates and real wealth, which increases household expenditures. Trade models do not have these channels, and they likely overestimate the negative effects or underestimate the positive effects on total output and employment from increased Chinese import competition. They lack some important aggregate demand channels, which are not likely second order.

1 Introduction

Macroeconomics does not play much of a role in trade models. This paper considers whether the role should be larger. When computing, say, the effects of a productivity increase in China on the U.S. economy, how much is lost if macro effects are ignored? There are a number of recent trade papers analyzing the effects of import competition from China on the United States. Autor, Dorn, and Hanson (2013) (ADH) find that exposure to Chinese import competition in U.S. local labor markets has a negative effect on manufacturing employment in the local market

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and on nominal wages outside the manufacturing sector. They find large effects. For example, they find that rising exposure to Chinese import competition explains 21 percent of the decline in U.S. manufacturing employment between 1990 and 2007 (p. 2140). They note in the conclusion (p. 2159) that theory suggests that trade with China should yield positive overall gains for the U.S. economy. Total effects on the economy are not estimated in their paper. Import prices are exogenous in their model, which rules out estimating overall effects. But given the large estimated losses, there must be large gains elsewhere.

Pierce and Schott (2016) (PS) find negative U.S. manufacturing employment effects after the United States granted Permanent Normal Trade Relations (PNTR) to China in 2000. They do not attempt to estimate the overall effects on the U.S. economy from this change. Acemoglu, Autor, Dorn, Hanson, and Price (2016) (AADHP) find very large effects from rising Chinese import competition. They estimate job losses from this competition over 1999–2011 of between 2.0 and 2.4 million. This estimate includes what they call "aggregate demand spillovers" (p.S̃183) from the initial shocks. They view any possible positive aggregate demand effects from a lower aggregate price level as second-order and do not consider this possible channel (p. S149, footnote 14). Their analysis thus implies large losses from trade.

Caliendo, Dvorkin, and Parro (2019) (CDP) are also interested in the effects on the U.S. economy of increased Chinese import competition. Their approach is quite different from that of the papers just mentioned. They construct a general equilibrium model of 22 sectors, 38 countries, and 50 U.S. states for the 2000–2007 period. They use the model to estimate what the U.S. economy would have been like had there been no China shock—no increase in Chinese productivity. They also find large negative effects on U.S. manufacturing employment from the China shock. However, the net effect on a measure of U.S. welfare in their model and on U.S. GDP is slightly positive. The gains in some sectors slightly offset the losses in others. As extensive as this model is, it does not include some of the macro effects discussed below. More will be said about this later.

The macro model used in this paper is my multicountry econometric model, denoted the "MC model," discussed next. The model is used to estimate the effects of lower Chinese export prices on the world economy, particularly on the U.S. economy. The aggregate effects on the United States are positive—aggregate output and employment are higher—and the channels that lead to these effects differ somewhat from those in trade models. They arise through real income, real wealth, interest rate, and exchange rate effects.

Section 2 outlines the MC model and the methodology behind it. A China shock is then analyzed in Section 3, first qualitatively and then quantitatively. Section 4 discusses some of the differences between the MC model and trade models.

2 The MC Model

The latest version of the MC model is in a document on my website, "Macroeconometric Modeling: 2018," which will be abbreviated "MM". Most of my past macro research, including the empirical results, is in MM. It includes chapters on methodology, econometric techniques, numerical procedures, theory, empirical specifications, testing, and results. The results in my previous macro papers have been updated through 2017 data, which provides a way of examining the sensitivity of the original results to the use of additional data.

The model of the United States is a subset of the MC model, and it will be denoted the "US model." The MC model of all the other countries will be denoted the "ROW model." There are 37 countries in the MC model for which stochastic equations are estimated. There are 25 stochastic equations for the United States and up to 10 each for the other countries. The total number of stochastic equations is 232, and the total number of estimated coefficients in these equations is about 1,000. In addition, there are 797 bilateral trade share equations estimated, so the total number of stochastic equations is 1,029. The total number of endogenous and exogenous variables, not counting various transformations of the variables and the trade share variables, is about 1,700. Trade share data were collected for 56 countries. Counting an "all other" category, the trade share matrix is 57×57.

The estimation periods begin in 1954 for the United States and as soon after 1960 as data permit for the other countries. The periods for the trade share equations begin in 1976:1 or later. The periods end as late as 2017:4. The estimation technique is two stage least squares (2SLS) except when there are too few observations to make the technique practical, where ordinary least squares (OLS) is used. OLS is used to estimate the trade share equations. The estimation accounts for possible serial correlation of the error terms. The variables used for the first stage regressors for a country are the main predetermined variables in the model for the country.

There is a mixture of quarterly and annual data in the model. Quarterly equations are estimated for 14 countries, and annual equations are estimated for the remaining 23. However, all the trade share equations are quarterly. There are quarterly data on the variables that feed into the trade share calculations, namely the price of exports per country and the total value of imports per country.

It is too much to explain the model in one paper, and I will rely on MM as the reference. Think of MM as the appendix to this paper. In what follows the relevant sections in MM will be put in brackets.

The modeling methodology is discussed next, followed by outlines of the US and ROW models. The focus in this discussion is on features of the model that pertain to the China experiment.

The Cowles Commission (CC) Approach

What I call the CC approach [MM, 1.1] is the following. Theory is used to guide the choice of left-hand-side and right-hand-side variables for the stochastic equations in a model, and the resulting equations are estimated using a consistent estimation technique like 2SLS. Sometimes restrictions are imposed on the coefficients in an equation, and the equation is then estimated with these restrictions imposed. It is generally not the case that all the coefficients in a stochastic equation are chosen ahead of time and thus no estimation done. In this sense the methodology is empirically driven and the data rule. Some argue that models specified using the CC approach are ad hoc, but this is not the case. Behavioral equations of economic agents are postulated and estimated. The CC approach has the advantage of using theory while keeping close to what the data say.

Typical theories for these models are that households behave by maximizing expected utility and that firms behave by maximizing expected profits. The theory that has been used to guide the specification of the MC model is discussed in [MM, 3.1, 3.2]. In the process of using a theory to guide the specification of an equation to be estimated there can be much back and forth movement between specification and estimation. If, for example, a variable or set of variables is not significant or a coefficient estimate is of the wrong expected sign, one may go back to the specification for possible changes. Because of this, there is always a danger of data mining—of finding a statistically significant relationship that is in fact spurious. Testing for misspecification is thus (or should be) an important component of the methodology. There are generally from a theory many exclusion restrictions for each stochastic equation, and so identification is rarely a problem—at least based on the theory used.

The transition from theory to empirical specifications is not always straightforward. The quality of the data is never as good as one might like, so compromises have to be made. Also, extra assumptions usually have to be made for the empirical specifications, in particular about unobserved variables like expectations and about dynamics. There usually is, in other words, considerable "theorizing" involved in this transition process. In many cases future expectations of a variable are assumed to be adaptive—to depend on a few lagged values of the variable itself, and in many cases this is handled by simply adding lagged variables to the equation being estimated. When this is done, it is generally not possible to distinguish partial adjustment effects from expectation effects—both lead to lagged variables being part of the set of explanatory variables [MM, 1.2].

This methodology differs substantially from that behind the specification of DSGE models. For these models the theory is much tighter (more restrictive), rational expectations is assumed, and there is considerable calibration. These differences are discussed in Fair (2019), which also summarizes some of the main results from my macroeconmetric modeling—empirical points that should be taken into account in constructing macro models.

The US Model

The following is a brief discussion of the main estimated equations. All the expenditure equations are in real terms. The following discussion of the explanatory variables ignores possible lagged dependent variables. A complete discussion of the US model, both the theory and the empirical specifications, is in [MM, 3.2, 3.6].

There are four expenditure equations of the household sector—consumption of services, nondurables, and durables, and housing investment—and the key explanatory variables are disposable income, interest rates, lagged wealth, age distribution variables, and lagged stocks for the durable and housing equations. There are four household labor supply equations—the labor force of males 25-54, females 25-54, all others 16+, and the number of people holding more than one job. The key explanatory variables are the real wage rate, lagged wealth, and the unemployment rate. Lagged wealth has a negative effect on labor supply—a negative income effect. The unemployment rate has a negative effect and is picking up discouraged worker effects.

There are six important stochastic equations of the firm sector. Plant and equipment investment depends on output, lagged excess capital, and interest rates.

Production depends on sales and the lagged stock of inventories. The demand for jobs and hours per job depend on output and lagged excess labor. In the two price and wage rate equations the price level depends on the wage rate, the import price index, and the unemployment rate. The wage rate and import price index are cost variables, and the unemployment rate is the demand variable. The wage rate depends on productivity and the price level. The fact that the import price index is an explanatory variable in the domestic price equation—the equation determining the price level of the firm sector—is important for the present analysis. The index is highly significant in the equation and also in almost all of the domestic price equations for the other countries. [MM, 3.6.4, 3.7.2] If, say, import prices fall, the aggregate estimates are picking up the behavior of firms lowering their prices to compete with the lower prices of imported goods. Also, prices of inputs that are imported may be lower, which may lead to lower domestic output prices.

There is an estimated interest rate rule of the Fed. The short term interest rate depends on inflation and the unemployment rate. The Fed is estimated to "lean against the wind." Long term interest rates are affected by the short term rate through estimated term structure equations.

There is an estimated import equation, where the level of imports depends on disposable income, lagged wealth, and the domestic price level relative to the import price index.

A key property of the US model from the perspective of this paper is the effect on the economy of a change in the import price index (PM), ignoring for now rest-of-world effects. Let PF denote the price level for the firm sector. As just noted, a decrease in PM leads to a decrease in PF since PM is an explanatory variable in the firm price equation. The coefficient estimate in the PF equation is such than when, say, PM decreases by 1 percent, PF decreases by less than 1 percent, and so PF/PM rises, which increases the demand for imports through the estimated import equation. The estimaated price and wage equations are such that a fall in PF does not result in as large a fall in the nominal wage rate (the nominal wage rate lags the price level), and so the real wage rate rises. This leads to an increase in real disposable income, which has a positive effect on household expenditures. In addition, the fall in PF leads to a rise in real wealth, which also has a positive effect on household expenditures. Some of the increase in household expenditures is on domestically produced goods and services and some on foreign produced goods and services. The increase in expenditures on domestically produced goods and services is expansionary, and so a decrease in PM leads to an increase in aggregate output and then to increases in jobs and hours per job from the firm-sector equations. As noted above, wealth has a negative effect on labor supply, and so the increase in real wealth leads to a decrease in the labor force through the labor force participation equations. This, other things being equal, has a negative effect on the unemployment rate. The increase in employment also has a negative effect, and so the unemployment rate is lower. The effect on the short term interest rate set by the Fed is ambiguous since inflation is lower and the unemployment rate is lower.

The ROW Model

There are estimated models for 36 other countries. These models are not as detailed as the US model. All the countries are linked by estimated trade share equations. Table 1 lists the main variables in each country's model and the main explanatory variables in the estimated equations. If there is no subscript on a variable, it is for country i. If there is a subscript j, this represents all the other countries in the model. The expenditure variables are real and are in units of 2010 local currency (lc). A variable with a $ at the end is in units of 2010 U.S. dollars. E is the exchange rate, lc/$, and so an increase in E is a depreciation of the country's currency relative to the U.S. dollar. $E10$ is the exchange rate in 2010. A variable like $(E10/E)PX$ is thus the export price index in 2010 dollars, which is denoted $PX\$$. PX is in units of lc/2010lc, and $PX\$$ is in units of $/2010$.

Table 1
Model for Country i

Identities		
(1) Y	$= C + I + G + EX - IM$,	GDP (aggregate output)
(2) $PX\$$	$= (E10/E)PX$,	export price index, \$/2010\$
Estimated equations		
(3) IM	$f(+Y, +PY/PM)$,	imports
(4) C	$f(+Y, -RS)$,	consumption
(5) I	$f(+Y, -RS)$,	investment
(6) PY	$f(+Y, +PM)$,	domestic price level
(7) RS	$f(+Y, +PY)$,	interest rate
(8) E	$f(+PY/PY_{us}, -RS/RS_{us})$,	exchange rate
(9) PX	$f(+PY, +(E/E10)PW\$)$,	export price index, lc/2010lc
(10) J	$f(+Y)$,	employment
Trade share calculations		
Estimated equations		
(11) α_{ijt}	$f(-PX\$/PX\$_j, +\alpha_{ijt-1})$,	trade shares
Identities		
(12) EX	$f(+IM_j, trade\ shares)$,	exports
(13) PM	$f(+PX\$_j, E, trade\ shares)$,	import price index
(14) $PW\$$	$f(+PX\$_j)$,	world price index

Notes:
- lc = local currency, expenditures are in 2010lc,
- a sign denotes the sign of the effect,
- subscript j refers to all countries except i.

Simplifications from the MC model:
- functional forms omitted,
- possible lagged dependent variables omitted,
- adjustments from merchandise to total exports and imports omitted,
- Y in (6) represents output gap,
- PY in (7) represents inflation,
- long term interest rate equation omitted,
- RS in (4) and (5) may represent the long term interest rate.
- Excess labor variable omitted from (10).

Table 1 is simplified relative to the complete MC model, as listed at the bottom of the table. Regarding the estimated equations in the table, the level of imports depends on output and the domestic price level relative to the import price index. Consumption and investment depend on output and the interest rate. The domestic price level depends on output and the import price index. The short term interest rate depends on output and the price level. It is determined by an estimated interest rate rule of the country's monetary authority. The exchange rate depends on the domestic price level relative to the U.S. price level and on the interest rate relative to the U.S. interest rate. The export price index depends on the domestic price level and on an index of world prices. In the estimation the weights on the domestic price level and the index of world prices are constrained to sum to one. A large estimated weight on the index of world prices means that the country is primarily a price taker in the world market. Finally, employment is a function of output.

Note that wages and wealth do not appear in Table 1. It is difficult to get time series data on these variables. This means that there are no real wage rate and real wealth effects in the other countries' models. Other things being equal, a decrease in PY is expansionary because it leads the monetary authority to lower the interest rate (RS), which stimulates consumption and investment. However, a potentially important channel is missing by having no real wage rate and real wealth effects, and so the the expansionary effects of a decrease in import prices have probably been underestimated for countries other than the United States.

α_{ijt} is the share if i's exports to j out of the total imports of j in quarter t. It depends on i's export price index relative to the export price indices of all the other countries. The export prices are all in \$ per 2010\$. The trade share equations are discussed in the next subsection. The level of exports of country i depends on the imports of all the other countries and the trade shares. The import price index for country i, PM, depends on the export price in dollars of each country weighted by the share of country i's imports from that country multiplied by $E/E10$ to convert to local currency. The index of world prices is the nominal value of the sum of world exports in dollars divided by the sum of the world exports in 2010 dollars. The summations exclude the own country and all the oil exporting countries.

Each of the stochastic equations in the MC model has been subject to a number of tests. Lagged values have been added to test for dynamics. The errors have been tested for serial correlation. A time trend has been added to test for trend effects. Two stability tests have been performed: Andrews (2003) end of sample stability test and Andrews and Ploberger (1994) stability test. The results of the tests are summarized in [MM, 3.6.11, 3.7.3]. Not every equation passes every test, but overall the results seem good. A particular specification is not chosen if it does poorly in the tests.

The equations are estimated under the assumption that all variables are trend stationary. If this assumption is violated, the estimated standard errors will be off. One can examine the accuracy of the estimated standard errors based on the asymptotic formulas using the bootstrap procedure. This is done in Fair (2003), with updated results in [MM, 3.9.1]. The asymptotic formulas reject too often, but the errors are not large. The results suggest that little is lost by using the asymptotic formulas.

Trade Share Equations

There is assumed to be one good per country, and the goods are imperfect substitutes. The data are quarterly and are from the Direction of Trade statistics. They are for merchandise exports and imports. The earliest possible quarter is 1960:1 and the latest is 2016:4. There are 56 countries plus an "all other" category, denoted AO. The trade share matrix is thus 57$\times$57.

Trade shares have been computed for each pair of countries. As noted above, a_{ijt} denotes the share of i's merchandise exports to j out of the total merchandise imports of j in quarter t, where i runs from 1 to 56 and j runs from 1 to 57.

One would expect a_{ijt} to depend on country i's export price relative to an index of export prices of all the other countries. The empirical work consists of trying to estimate the effects of relative prices on a_{ijt}. A separate equation is estimated for each i, j pair. The equation is the following:

$$\begin{aligned} \log(a_{ijt} + .00001) &= \beta_{ij1} + \beta_{ij2}\log(a_{ijt-1} + .00001) \\ &+\beta_{ij3}(PX\$_{it}/(\textstyle\sum_{k=1}^{56} a_{kjt-1}PX\$_{kt}) + u_{ijt}, \\ &t = 1, \ldots, T, \beta_{ij3} < 0. \end{aligned} \tag{1}$$

$PX\$_{it}$ is the price index of country i's exports, and $\sum_{k=1}^{56} a_{kjt-1}PX\$_{kt}$ is an index of all countries' export prices, where the weight for a given country k is the previous quarter's share of k's exports to j out of the total imports of j. (In this summation $k = i$ is skipped.) Equation (1) says that a trade share in quarter t depends on the trade share in quarter $t-1$ and the relative price variable. If the relative price for quarter t changes from its value in quarter $t-1$, the trade share in quarter t is specified to change from its value in quarter $t-1$. This analysis is conditional on the lagged trade share. No attempt is made to explain why trade shares differ across pairs of countries. This is the job of trade theory.

With i running from 1 to 56, j running from 1 to 57, and not counting $i = j$, there are 3,192 ($= 56 \times 57$) i, j pairs. There are thus 3,192 potential trade share equations to estimate. In fact, data limitations prevent all equations from being estimated. Data did not exist for all pairs and all quarters. The estimation periods began in 1976:1 or later depending on data availability. If fewer than 87 observations were available for a given pair, the equation was not estimated for that pair. If the mean of a_{ijt} over the sample period were less than 0.005, the equation was not estimated. Estimated equations were rejected if the estimate of β_{ij2}, the coefficient of the lagged dependent variable, was less than zero or greater than 0.99. Also, if the estimate of β_{ij3} divided by 1.0 minus the estimate of β_{ij2}, which is the estimated long run effect, was less than -4.0, the equation was rejected. This led to 1,118 pairs being estimated.

Table 2
Summary Results for the 1,118 Trade Share Equations

Percentage of Correct and Incorrect Signs for $\hat{\beta}_{ij3}$	All Countries	Quarterly Countries
Correct Sign	71.3	70.5
Correct Sign, $\lvert t\rvert > 2.0$	31.7	34.9
Correct Sign, $\lvert t\rvert > 1.0$	51.3	55.6
Incorrect Sign	28.7	22.8
Incorrect Sign, $t > 2.0$	5.5	4.0
Incorrect Sign, $t > 1.0$	13.4	10.8

Average Size of the Coefficient Estimates that were of the Correct Sign	All Countries	Quarterly Countries
$\hat{\beta}_{ij3}$	-0.286	-0.202
$\hat{\beta}_{ij3}/(1-\hat{\beta}_{ij2})$	-1.263	-1.173

The estimation results are summarized in Table 2. The expected sign of β_{ij3} is negative, and 71.3 percent of the estimates were negative (797 out of 1,118). 31.7 percent of the estimates were negative with a t-statistic in absolute value greater than 2.0, and 51.3 percent were negative with a t-statistic in absolute value greater than 1.0. Only 5.5 percent of the estimates were positive with a t-statistic greater than 2.0, and only 13.4 percent were positive with a t-statistic greater than 1.0. The results for the quarterly countries only are similar. There is thus support for equation (1). The average size of the negative estimates of β_{i3} is -0.286, with a long run average size of -1.263. In the final specification of the MC model a trade share equation with the wrong estimated sign was dropped and the trade share was taken to be exogenous. There are thus 797 estimated trade share equations in the model. The online appendix to this paper lists the 797 estimated equations.

Finally, in the solution of the model the predicted values of α_{ijt}, say, $\hat{\alpha}_{ijt}$, do not obey the property that $\sum_{i=1}^{56} \hat{\alpha}_{ijt} = 1$. Unless this property is obeyed, the sum of total world exports will not equal the sum of total world imports. For solution purposes each $\hat{\alpha}_{ijt}$ was divided by $\sum_{i=1}^{56} \hat{\alpha}_{ijt}$, and this adjusted figure was used as the predicted trade share. In other words, the values predicted by the equations in (1) were adjusted to satisfy the requirement that the trade shares sum to one.

3 Effects of a China Shock

Qualitative Discussion

A good way of comparing macro and trade approaches is to consider a common experiment. Given the recent trade literature, an obvious experiment is something that increases import competition from China. The experiment using the MC model is to lower China's export price index, PX_{ch}. There is an estimated equation for this variable, where the log of the export price index is a weighted average of the log of China's domestic price level and the log of an index of world prices—equation (9), Table 2. The estimated weight on the domestic price level is 0.49. PX_{ch} is thus endogenous and so cannot be changed exogenously. What was done instead for the experiment was to add -0.20 to the equation, roughly a 20 percent decrease. In the experiment PX_{ch} will thus not be exactly 20 percent lower because it is affected by the variables in the equation, which are endogenous.

As noted above, each country has an import price index that is a weighted average of the export prices of the other countries, where the weights are the trade shares. In the case of the China experiment a country's import price index will fall more the larger is the share of China's exports to the country. And the larger the fall in the country's import price index the larger will be the increase in its imports.

In this macro story the increase in imports is driven by the fall in Chinese export prices. From this perspective the trade literature discussed above starts too late in the game. ADH, PS, and AADHP begin with with employment changes induced by increased import competition from China. PS identify increased Chinese competition from PNTR. ADH and AADHP use non-U.S. exposure to Chinese imports to identify U.S. employment changes due to increased Chinese competition. CDP use the same identification strategy, but use the implied import changes to back out productivity increases in China, which are then taken as exogenous for the experiment. Although these experiments do not begin with prices, behind the scenes it must be that China is able to make inroads into, say, U.S. markets by lowering the prices of its exports (possibly because of productivity increases).

To return to the MC experiment, if there is no change in the Chinese exchange rate, then $PX\$_{ch}$ decreases the same percent as PX_{ch}. This decreases the U.S. import price index, which from the discussion in the previous section is expansionary. The firm-sector price level falls, as does the nominal wage rate, but the nominal wage rate falls less and so there is an increase in the real wage rate. This has a positive effect on household expenditures. Real wealth also increases, which also has a positive effect on household expenditures. Imports increase because the relative price of imports decreases, which is contractionary, but as will be seen, the net effect quantitatively is positive.

Consider next the qualitative effects on the rest of the world. It will be useful to use Table 1 as a guide in discussing the world wide effects of a fall in Chinese export prices. Consider a decrease in $PX\$_{ch}$. For a given country i the import price index, PM, falls—(12), which leads to a decrease in the domestic price index, PY—(6), which leads to a decrease in the export price index, PX—(9). If PY falls less than PM (which is quantitatively the case), the level of imports, IM, increases—(5).

Turn now to the trade share equations and calculations. Feeding into the trade share calculations are larger values of imports and lower values of export prices. Coming out of the calculations is the level of exports to each country from each country. In the process each trade share is computed from its estimated equation (unless the trade share is exogenous). The computed trade share for country i to country j depends on how much country i's export price index falls relative to those of the other countries, weighted by the appropriate lagged trade shares—equation (1) in the text. The level of exports from i to j depends on the trade share and the total level of imports of j. Conditional on the trade share, the larger is the increase in country j's imports, the large will be country i's exports. Also coming out of the trade share calculations is the import price index for each country—(13). Remember that China is part of these calculations. All was triggered by the exogenous decrease in China's export price. In the quantitative results below none of the decreases in the export prices of the other countries are as large in absolute value as the decrease in the Chinese export price, and so there is a large relative fall in China's export price. China's trade shares increase, and its exports increase—(12). This increases output—(1), which leads to an increase in its imports—(3) and domestic price level—(6).

Coming back to country i, total exports may rise or fall. On the plus side all countries are importing more, including China. On the minus side if the country is a large competitor with China (through the trade share calculations), it may lose out. Also, regardless of China, a country's export change depends on how large a change there is in the imports of countries that the particular country exports to. The export change also depends on how much the trade shares change, which depends on the size of the decrease in country i's export price relative to the decreases in the other countries' export prices.

For countries with estimated interest rate rules, the decrease in inflation leads to a lower interest rate—(7). This in turns stimulates consumption and investment—(4) and (5). The net effect on GDP, Y, is ambiguous—(1). It depends on the size of the increase in imports relative to the size of the increases in exports, consumption, and investment. If Y does decrease, this will further decrease the interest rate—(7), which will mitigate the decrease somewhat. Employment, J, moves in the same direction as Y—(10).

Turn finally to country i's exchange rate. Whether the country's currency depreciates or appreciates relative to the dollar depends on the change in its domestic price level relative to that of the United States and on the change in its interest rate relative to that of the United States—(8). If the currency depreciates (E increases), this will decrease its price of exports in dollars—(2), which feeds into the trade share calculations. Also, its import price index (in local currency) will increase—(13). Exchange rate effects can be important because they change a country's competitiveness, although exchange rate changes are hard to predict. The exchange rate equations in the MC model explain very little of the variation of the exchange rates.

As noted above, missing from the other countries' models are real wage rate and real wealth effects. If they were included the China experiment would be more stimulative than estimated.

The Experiment

As noted above, -0.20 was added to the Chinese export price equation, which is in logs. The simulation period is 2000-2007. The estimated residuals were added to the stochastic equations for this period and taken to be exogenous. This means that when the model is solved with no changes made there is a perfect tracking solution. The change is then made to China's export price equation and the model solved. The difference between the solution value and the actual value for each variable and period is the estimate of the effects on the change on that variable for that period. The results for China and the United States are presented in Table 3. Results are presented for China for 2002 and 2007, three and eight years after the change respectively. Results for the United States are presented for 2002:4 and 2007:4, twelve and 32 quarters after the change respectively.

Table 3
Summary Results for the
China Experiment

	China		United States	
	3Y	8Y	12Q	32Q
PM	-0.46	-1.33	-2.08	-4.43
PY	2.75	11.03	-0.47	-1.61
PX	-17.30	-14.71	-0.72	-1.98
$PX\$$	-17.30	-14.71	-0.72	-1.98
$PW\$$	-0.67	-2.10	-2.01	-3.90
IM	0.54	4.05	0.65	1.54
EX	7.78	9.81	0.08	-0.19
C	1.07	4.81	0.31	0.86
I	2.43	8.09	0.41	0.72
Y	3.00	7.27	0.18	0.42
RS	0.00	0.00	-0.04	-0.03
E	0.00	0.00	-	-

Notes:
- See the notation in Table 1.
- Values are percent changes from the base run in percentage points except for RS.
- For RS values are absolute changes in percentage points.
- Y = years, Q = quarters.
- C for the U.S. is household expenditures

Effects on China and the United States

The following discussion will focus on results after 8 years or 32 quarters. Consider China first. Exports are 9.81 percent higher (after 8 years) than in the base case from the effects of the lower Chinese export prices. This stimulates domestic demand, and so imports, consumption, and investment are higher. The positive effects from exports, consumption, and investment outweigh the negative effects from imports, and so GDP is higher (by 7.27 percent). This stimulus leads to an increase in Chinese domestic prices: the domestic price level is higher by 11.03 percent. Note that the price of exports is not lower by the full 20 percent of the shock; it is only down 14.71 percent. It is endogenous and depends on the domestic price level and the world price index. The former is up and the latter is down, and the net effect is positive, leading the price of exports not to fall by the full 20 percent. There is no interest rate nor exchange rate equation for China and so no estimated interest rate nor exchange rate effects. If there were, it is likely that the Chinese central bank would raise the interest rate (since output and prices are higher), which would likely lead to an appreciation of the yuan. The expansion would thus not be as large as estimated in Table 3.

Consider now the United States. The price of imports is lower by 4.43 percent, which leads the domestic price level to be lower by 1.61 percent. This, as discussed above, stimulates household expenditures through real wage rate and real wealth effects. Household expenditures are 0.86 percent higher, which has a positive effect on GDP. The increase in GDP in turn has a positive effect on firm investment (0.72 percent higher) and imports (1.54 percent higher). The final effect on GDP is that it is 0.42 percent higher. Although not shown in the table, the number of jobs is 0.44 percent higher, which is an increase of 588,000 jobs. Imports are up because of the demand stimulus and also because the price of imports fell more than did the domestic price level. The estimated Fed rule calls for a decrease in the short term interest rate because of lower prices, but an increase because of higher output, and the net effect is that the interest rate changed very little: it fell 0.03 percentage points.

U.S. export prices fell due to a fall in the domestic price level and the world price index. As will be seen, export prices of other countries also fell, and so it is not clear that a fall in U.S. export prices will lead to a rise in U.S. exports. In addition, the dollar appreciated relative to other currencies, which has a negative effect on exports. In fact, U.S. exports were little changed; exports fell by 0.19 percent.

These quantitative results are as expected from the qualitative discussion. The net effect on U.S. output and employment is positive because of the effects of lower prices.

Effects on Other Countries

The results for eight other countries (out of 35) are presented in Table 4, seven quarterly countries and Mexico, which is an annual country. As noted above, there are no real wage and real wealth effects estimated for other countries, and so any stimulation from these effects is not accounted for.

For every country the price of imports is lower, due to the effects of the lower Chinese export prices. Also, for every country except Mexico the domestic price level is lower. As noted above, the import price index is a significant explanatory variable in most of the domestic price equations; this is a very robust finding. Mexico does not have an estimated domestic price equation, which is why it shows no effect on the domestic price level.

For every country except Korea and Mexico imports rise, which is because import prices fell more than did the domestic price level. The relative price variable is not in the Korea import equation, which is why Korean imports did not rise. More will be said about Mexico later. For every country the price of exports in dollars fell, due to the fall in the domestic price level and world export prices. Whether exports increase or decrease in this case depends on the fall in a country's export price index relative to other countries' indices and on the trade share calculations. Exports rose slightly for Japan, France, the United Kingdom, and Korea and fell for the others.

The net effect on total output is positive for Korea and negative for the others. The monetary authorities responded to lower prices and lower output by lowering the short term interest rate (except for Korea and Mexico, which do not have an estimated interest rate equation). The lower interest rates have positive effects on consumption and investment. The decreases in the interest rates were larger

Table 4
Summary Results for the China Experiment

	Canada		Japan		France		Germany	
	12Q	32Q	12Q	32Q	12Q	32Q	12Q	32Q
PM	-1.09	-2.39	-3.36	-3.71	-0.81	-1.43	-1.18	-2.10
PY	-0.19	-1.85	-0.27	-0.74	-0.38	-1.15	-0.15	-1.02
PX	-0.52	-2.14	-1.13	-2.19	-0.77	-1.47	-0.47	-1.27
$PX\$$	-0.62	-2.65	-1.10	-2.43	-0.98	-2.98	-0.68	-2.78
$PW\$$	-1.93	-3.75	-1.92	-3.80	-1.92	-3.75	-2.00	-3.82
IM	0.50	0.57	0.62	1.28	0.32	0.41	0.38	1.10
EX	-0.57	-2.30	0.13	0.53	-0.04	0.03	-0.16	-0.16
C	-0.12	-1.12	-0.02	-0.08	-0.06	-0.03	-0.05	-0.35
I	-0.11	-1.03	0.00	0.00	0.03	0.36	-0.05	-0.21
Y	-0.41	-1.78	-0.07	-0.14	-0.11	-0.03	-0.19	-0.69
RS	-0.09	-0.42	-0.01	-0.03	-0.12	-0.40	-0.12	-0.40
E	0.10	0.53	-0.03	0.24	0.21	1.55	0.21	1.55
	U.K.		Australia		Korea		Mexico	
	12Q	32Q	12Q	32Q	12Q	32Q	3Y	8Y
PM	-1.17	-2.41	-1.88	-3.22	-2.28	-3.08	-1.01	-2.64
PY	-0.57	-1.87	-0.21	-0.98	-0.11	-0.31	0.00	0.00
PX	-0.95	-2.18	-0.83	-1.94	-0.93	-1.66	-1.01	-2.13
$PX\$$	-1.05	-3.05	-0.93	-2.29	-1.12	-2.51	-1.01	-2.13
$PW\$$	-1.90	-3.74	-1.88	-3.73	-1.88	-3.75	-1.76	-3.71
IM	0.12	0.11	0.39	0.38	-0.03	-0.11	0.40	-0.16
EX	-0.04	0.05	-0.41	-0.08	-0.65	0.13	-1.13	-4.66
C	-0.01	-0.01	-0.11	-0.27	-0.07	-0.06	-0.39	-2.29
I	-0.01	-0.02	-0.10	-0.20	-0.01	-0.03	0.00	0.00
Y	-0.05	-0.03	-0.22	-0.30	-0.24	0.07	-0.65	-2.81
RS	-0.09	-0.12	-0.19	-0.38	0.00	0.00	0.00	0.00
E	0.10	0.90	0.09	0.35	0.20	0.88	0.00	0.00

See notes to Table 3

than the decrease in the U.S. rate, and this led to a depreciation of the countries' currencies relative to the dollar (E is higher). The prices of exports in dollars thus fell more than the prices of exports in local currency. This has a positive effect on exports.

There was a fairly large fall in Canada's exports (-2.30 percent), which led to a fairly large fall in total output (-1.78 percent). The same is true for Mexico. For all countries the fall in the price of exports was much smaller than the fall in the price of exports of China, and so all countries lost market share to China. Canada and Mexico are large exporters to the United States, and the trade share estimate and calculations are such that there are large decreases of Canadian and Mexican exports to the United States. These two countries are the most effected of all the countries by the China shock. This result depends, other things being equal, on the trade share coefficient estimates, and in this sense they are empirically based.

The main point about the results for the other countries is that output is generally slightly lower because of the loss of exports to China. The declines are smaller than otherwise because of lower interest rates and depreciated currencies and because world demand is stimulated by increases in most countries' imports. Again, this is absent real wage rate and real wealth effects, which would be stimulative.

4 Comparison with Trade Models

I began this study thinking I could compare the experimental results from the MC model just described to those from a model like the CDP model, but the model building methodologies are not similar enough for this to be sensible. Following the CC approach, the MC model is a standard textbook simultaneous equations models, nonlinear. It can be easily solved numerically using Gauss-Seidel. The coefficient estimates are based on data as far back as 1954.

The CDP model is a model of 22 sectors, 37 countries not counting the United States, and 50 U.S. states. For a given sector there is potential trade between each pair. Also, for a given sector there is potential labor migration between each pair of U.S. states. Trade elasticities are estimated. If trade elasticities differed across sectors and pairs, there would be $22 \times 88 \times 87 = 168,432$ parameters to estimate. If fact, estimates are obtained for only 12 sectors, so the potential number of parameters is 91,872. If these parameters were constant across time, they could in principle be estimated with enough data over time. The assumption is made, however, that for a given sector all the parameters are the same, so there are only 12 parameters to estimate. These are estimated using cross section data for 1993. The theoretical specification of the model is tight, based on the assumption of perfect foresight, and the model is constructed to have a steady state. The structure is such that the model cannot be solved in closed form without the assumption of equal sector elasticities across pairs. A similar story concerns migration elasticities. There are potentially 29,400, but they are all assumed to be the same, so only one parameter is estimated. In this case it is estimated using data across time. Again, this assumption is required to be able to solve the model in closed form. There is one calibrated parameter in the model, the discount rate, set at 0.99 per quarter.

The China experiment that CDP run is similar to the one in this paper in that there is increased Chinese import competition. For comparison purposes, it is informative to consider how, say, exports from Germany to France are affected in the experiment. For the MC model there are five estimated equations that are important for this determination: the domestic price equation for Germany—(6) in Table 1, the import equation for France—(3), the export price equation for Germany—(9), the Euro exchange rate equation—(8), and the trade share equation for $\alpha_{GE,FR}$. The first equation is estimated for the 1961:1-2017:2 period, the second for 1961:1-2017:4, the third for 1965:1-2016:4, the fourth for 1972:2-2017:4, and the trade share equation for 1976:1-2016:4. In the solution after the shock (where, of course, the entire MC model is involved), the effects on the first four variables are listed in Table 4. For reasons discussed in the previous section, Germany's price of exports in dollars falls (by 2.78 percent after 32 quarters). For the trade share calculations this price needs to be compared to $\sum_{k=1}^{56} a_{kjt-1} PX\$_{kt}$ in equation (1) in the text, where j is France and the summation skips Germany. Although not shown in the table, this variable decreased more than did $PX\$_{GE}$ (driven by the large fall in the Chinese export price), and so the ratio in equation (1) increased, which has a negative effect on the trade share $\alpha_{GE,FR}$. On the other hand, French total imports rose, and the net effect on exports from Germany to France was positive: the level of exports rose 0.41 percent, which is \$123 million. This result could clearly go either way; the sign depends on the sizes of the coefficient estimates in the various equations. Regarding exports from France to Germany, it turns out that these are down 0.51 percent after 32 quarters—\$104 million.

For the CDP model the exports from Germany to France are based on the 12 estimated elasticities, estimated using 1993 data. The level of detail is much larger since there are 12 tradeable sectors compared to one good per country for the MC model. On the other hand, there are many more coefficients estimates in the MC model—about 1,000 in the estimated structural equations and $797 \times 3 = 2,391$ in the estimated trade share equations—based on data back as early as 1954. The empirical strategies are thus vastly different. In this case, unlike in the DSGE case, the difficultly of making comparisons is not because the CDP model is calibrated, which is isn't except fot the discount factor. It's that so much is based on so few estimated coefficients.

5 Conclusion

Focusing on the United States, a fall in Chinese export prices is stimulative in the MC model. Domestic prices fall, real wage rates and real wealth rise, and household expenditures increase. It may also be that the Fed lowers the interest rate due to lower prices, which is stimulative, although this is ambiguous since higher output has a positive effect on the interest rate through the estimated Fed rule. It may also be that the dollar appreciates, which has a negative effect on output. But the net effect in the model is positive. These channels are missing from most trade models, and so in the case of the China experiment the models have likely overestimated the negative or underestimated the positive employment effects of increased Chinese import competition.

Note that this is an aggregate result. It may be that some sectors and regions in a country or state are adversely affected by increased Chinese import competitions, where output and employment are down. Behind the aggregate result is the situation that other sectors and regions (and even possibly individuals within the negatively affected sectors and regions) are helped by the increased aggregate demand caused by the lower prices.

Finally, from the perspective of the Cowles Commission approach, trade models are far removed from the data. The level of disaggregation can be very large, but few parameters are estimated relative to the size of the models. Also, the dynamics don't seem likely to be well captured. A question like the effects on the economy from increased Chinese import competition is a dynamic question, but time series data are used sparingly in trade models. Many of the paramter estimates are typically based on one cross section of data. Dynamic results from many trade models thus have little empirical support, in addition to not taking into account macro effects.

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