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THE ASIAN FINANCIAL CRISIS AND GLOBAL ADJUSTMENTS: IMPLICATIONS FOR US AGRICULTURE*

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This study investigates the impact of the recent Asian financial crisis on global economic adjustment and its implication for US agriculture using a multi-country, multi-sector dynamic intertemporal general equilibrium model with endogenously modelled financial markets. The simulation results show that the crisis in Asia reduces not only US exports but also interest rates and the cost of intermediate inputs of production, stimulating US domestic economic activity in interest-sensitive sectors, and driving up demand for agriculture products. However, this stimulus of domestic demand may or may not offset the negative impact of declining exports.
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1. Introduction

The dependence of US agriculture on the world economy has changed significantly during the past three decades. US agriculture has become more closely integrated in the world economy through a variety of channels. Export markets are increasingly important for US producers. The proportion of US farm products exported more than doubled during the past three decades in response to greater liberalization of markets and US comparative advantage in land-extensive and capital-intensive agriculture, and now accounts for about 20% of US total agricultural production, at least double the average export share for other US industries.[1] Furthermore, American agriculture now depends to a much greater extent than before on purchased inputs and borrowed capital, the costs of which are determined by supply and demand conditions in an interdependent US and global economy. The combination of a flexible exchange rate system and a well integrated international capital market means that changes in exchange rates and interest

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[1] The share calculation used here is based on the ratio of the f.o.b. value of US agriculture and food exports ($55 billion in the 1995 financial year) to gross farm income ($211 billion in 1995). This share probably overstates the real share because the value added component of exports is not netted out. According to the GTAP database, the share of US agriculture production exported was 9% in 1995.

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rates have become more important determinants of agricultural production and trade performance today than they were twenty years ago. In the meantime, the growing share of income of rural households from non-farm employment reduces the relative importance of farming as a primary source of income for farmers in many industrial countries, and off-farm employment now accounts for more than two-thirds of total farm household income in the United States. As a result, agricultural commodity prices and the income of American farmers have become increasingly sensitive to the economic environment outside agriculture.

Given these changed economic conditions, unexpected economic disturbances in the global economy such as the recent Asian financial crisis undoubtedly have a significant impact on US agriculture and farm income. However, most attention in the US farm community has focused on the merchandise trade impact of the crisis—declining exports, rising imports and a deteriorating agriculture trade surplus. This is understandable, given the importance of the Asian market to the US agriculture and food sector—about 40% of US agriculture and food exports go to Asia. Less attention has been given to the far-reaching global adjustments necessitated by the crisis in Asia and its implications for US agriculture.

There are at least two crucial missing ingredients from this narrow trade perspective. First, the crisis has shifted capital flows from affected Asian countries towards industrial countries, especially the United States, reducing real interest rates and lowering capital costs in those economies, which tends to boost interest-sensitive activities such as durable good demand (particularly housing) and business investment, thus stimulating domestic demand for agricultural products. Second, the economic slowdown in Asia has reduced global demand for consumer products as well as for intermediate inputs such as energy and other basic raw materials, for which those affected Asian countries accounted for a significant share of global demand. In the meantime, the dramatic depreciation of South-east Asian currencies has reduced the US dollar prices of commodities such as timber, rice, natural rubber and vegetable oil, of which the affected Asian economies are important world suppliers. This tends to reduce inflation and lower the cost of agricultural production in the United States and other industrial countries. Ignoring these phenomena misses key parts of the global adjustment story, and therefore precludes a correct evaluating of the overall impact of the Asia crisis on the US food and agricultural industries.

This paper analyses the global adjustment process induced by the Asian financial crisis and its implications for US agriculture using a multi-country, multi-sector dynamic intertemporal general equilibrium model with endogenously modelled financial markets—the G-Cubed (Agriculture) model. The simulation results illustrate that the crisis in Asia has not only reduced US agricultural exports but has also reduced global real interest rates and the cost of intermediate inputs of production, and through these channels has stimulated US domestic demand for agricultural products. However, the stimulus to domestic demand may or may not offset the negative impacts of a decline in exports, depending on the relative reliance of each sector on domestic demand versus dependence on Asian markets.

The rest of the paper is organized as follows. The basic features of the model are outlined in Section 2. Section 3 summarizes how a baseline of the model is generated and how the Asian crisis is simulated. Section 4 discusses the likely global adjustment process induced by the crisis and its implication for US agriculture based on simulation results. Conclusions are given in Section 5.

2. Structure of the G-Cubed (Agriculture) model

The G-Cubed (Agriculture) model is an extension of the G-Cubed Multi-country model[2] with a particular focus on agriculture. Like the latter, this extended model incorporates forward-looking behaviour and intertemporal budget constraints on firms, households, governments and nations (the latter through accumulations of foreign debt); it also contains substantial regional disaggregation and sectoral detail. These features give the model the capacity to evaluate macroeconomic shocks that may have large effects on small segments of the economy such as the agricultural sector.

The key features of G-Cubed (Agriculture) model can be summarized as follows:

- The demand and supply sides of modelled economies in both real and financial markets are specified.
- Household behaviour in the short run is a weighted average of neoclassical optimizing behaviour and *ad hoc* "liquidity-constrained" behaviour.
- The real side of the model is disaggregated to allow for production and trade of multiple goods and services within and across economies.
- Financial markets are integrated with real side of the economy. Each financial asset represents a claim over real resources—money over purchasing power, bonds over future tax revenues, equity over the future dividend stream of a firm, and foreign assets over future exports of the debtor country.
- Intertemporal budget constraints are imposed so that agents and countries cannot forever borrow or lend without undertaking the required resource transfers necessary to service outstanding liabilities.
- Asset markets are linked globally through the international mobility of financial capital.
- Agents arbitrage between different assets within countries and across countries, taking into account the fixity of physical capital stock in each sector in the short run.
- Labour markets may not clear in the short run.
- There is full short-run and long-run macroeconomic closure with macrodynamics at an annual frequency around a long-run Solow–Swan neoclassical growth model.
- The base line of the model is solved for a full rational expectations equilibrium at an annual frequency from 1993 to 2070.

The country and sectoral breakdown of the model are summarized in Table 1. The model consists of 12 economic regions: the United States, Canada, Japan, Australia, European Union (12 member countries), Mexico, Korea, the rest of the OECD, Taiwan, ASEAN, China, and rest of the world (ROW). Each region consists of 12 sectors of production plus a sector that creates capital goods for firms and a sector that produces capital goods for households. There is one energy sector, four primary agricultural sectors (food grains, feed grains, non-grain crops and livestock products), mining, fishing and forestry products and four manufacturing sectors (processed food, durable manufacturing, textile and apparel, and other non-durable manufacturing) and services.

Each region in the model has several economic agents: a representative household, a government, and a representative firm in each of the production sectors. These agents

[2] The G-Cubed model was originally developed by McKibbin and Wilcoxen (1992). It combines the dynamic macroeconomic modelling approach taken in the MSG2 model of McKibbin and Sachs (1991) with the disaggregated, econometrically estimated, intertemporal general equilibrium model of the US economy by Jorgenson and Wilcoxen (1990).

TABLE 1
OVERVIEW OF THE G-CUBED (AGRICULTURE) MODEL

Regions		Sectors
United States	(U)	Energy
Canada	(C)	Mining
Japan	(J)	Forestry and fish products
Australia	(A)	Agriculture
European Union	(E)	Food grains
Mexico	(M)	Feed grains
Rest of OECD	(O)	Non-grain crops
Korea	(K)	Livestock products
Taiwan	(T)	Manufacturing
China	(H)	Processed food
ASEAN	(N)	Durable manufacturing
Rest of the World	(L)	Textile and apparel
		Other non-durable
		Services
Agents		**Markets**
Households		Goods and services
Firms		Factors of production
Governments		Bond
		Equity
		Money
		Foreign exchange

interact in a range of markets—final goods, intermediate goods, factors of production, money, bond, equity and foreign exchange markets. The assumptions about how agents behave follow the original G-Cubed model. Each agent combines two types of behaviour: intertemporally optimizing behaviour, and liquidity-constrained behaviour (or "rule of thumb" behaviour). The relative weighting between the two types of behaviour is based on empirical evidence and the approach taken in the MSG2 model (McKibbin and Sachs, 1991). In the long run with no shocks, both types of behaviour are the same, but in the short run the rule of thumb behaviour ignores changes in expected future income or profit streams that intertemporal optimizing behaviour takes into account.

The economic behaviour of major agents and the role of financial markets in the model are summarized below. Readers should refer to McKibbin and Wang (1998) for detailed algebraic specification of the model, as well as the derivations in McKibbin and Wilcoxen (1992, 1999).

2.1 Firms

Each of the production sectors is represented by a single firm which chooses its variable inputs and its level of investment in order to maximize its stock market value subject to a multiple-input production function and a vector of prices which it takes as exogenous. For each sector, output is produced with inputs of capital, labour, land, energy and intermediate inputs from all other sectors. Land is used only in the four agricultural sectors. Intermediate goods are, in turn, aggregates of imported and domestic produced products that are imperfect substitutes (the Armington assumption). By constraining all agents in the model to

have the same preferences over the origin of goods, we require that, for example, the agricultural and service sectors have identical preferences over domestic oil and oil imported from the Middle East.[3] This accords with the input–output data we use and allows a very convenient nesting of production, investment and consumption decisions. The structure of production and demand in the model are shown in Figure 1.

In each sector the capital stock changes according to the rate of fixed capital formation less depreciation. One of the key assumptions in the model is that physical capital is costly to adjust and is sector-specific in the short run. Following the cost of adjustment models of Lucas (1967), Treadway (1969) and Uzawa (1969), we assume that the investment process is subject to rising marginal costs of installation.

The goal of each firm is to choose inputs to maximize intertemporal net-of-tax profits subject to its technology and capital accumulation constraints. The solution to this intertemporal optimization problem yields the condition that variable inputs must be hired to the point where the marginal productivity of these factors equals their prices relative to the output price. Based on this condition, the model is specified by cost functions and various component demand functions derived according to Shephard's lemma. The price of the output at each level of the tier structure is also the unit cost function, depending on the prices of variable inputs and the quantities of available fixed factors such as capital.

The rate of gross investment in each sector is a function of "Tobin's q" for that sector, where q is the increment to the value of the firm from an additional unit of investment. Following Hayashi (1979), we modify the investment function to improve its empirical properties by writing gross investment as a function not only of q, but also of the firm's current cash flow.

We assume that investment goods are supplied by a firm facing an optimization problem similar to those of the 12 industries described above. Like other industries, the investment

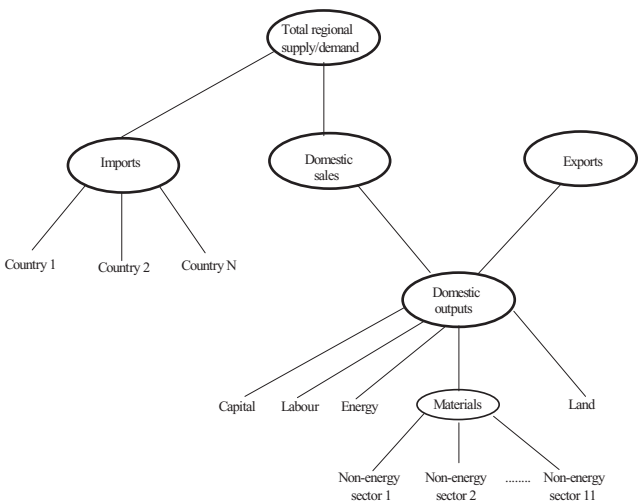

FIGURE 1. Commodity/sector nesting in G-Cubed (Agriculture) model

[3] This does not require that both sectors purchase the same amount of oil, or even that they purchase oil at all: only that they both feel the same way about the origins of oil they buy.

sector demands labour and capital services as well as intermediate inputs. The investment column in the input–output table is used to parameterize the investment sector's cost function. As with other sectors, there is a shadow price associated with investment in the investment goods sector. Production structure of the investment good is similar to Figure 1.

2.2 Households

Households consume goods and services in every period and also demand labour and capital services. Household capital services consist of the service flows of consumer durables plus residential housing. Households receive income by providing labour services to firms and the government, and from holding financial assets. They may also receive transfers from their government.

We assume that household behaviour can be modelled by a representative agent in each country who maximizes an intertemporal utility function subject to the constraint that the present value of consumption be equal to the present value of after-tax labour income (human wealth) plus initial financial assets. Human wealth in real terms is defined as the expected present value of a future stream of after-tax labour income. Financial wealth is the sum of real money balance, real government bonds in the hands of the public, net holdings of claims against foreign residents, and the value of capital in each sector.

The solution to this maximization problem is the familiar result that aggregate consumption is equal to a constant proportion of private wealth, where private wealth is defined as financial wealth plus human wealth.

Based on the evidence cited by Campbell and Mankiw (1987) and Hayashi (1982), we assume that only a portion of total consumption is determined by these intertemporally optimizing consumers who calculate expected future income streams, and that the remainder is determined by after-tax current income. This can be interpreted as liquidity-constrained behaviour or a permanent income model in which household expectations regarding income are backward-looking. It implies that total consumption is a weighted average of the forward-looking consumption and backward-looking consumption.

The household consumption problem is treated as a sequence of decisions. Households first decide on total consumption for each period as described above; then the total expenditure is allocated across goods and services based on preferences and relative prices. We assume that the household's preferences can be represented by a two-level nested constant elasticity of substitution utility function.[4] At the top tier of the utility function, total consumption is allocated across energy, a basket of non-energy goods (i.e. materials) including agricultural products, labour and capital services. Household capital services consist of the service flows of consumer durables plus residential housing. At the second tier, spending on non-energy goods is further disaggregated into demands for individual commodities. The allocation of total consumption expenditure across goods and services is assumed to be separable from the intertemporal allocation.

The supply of household capital services is determined by consumers themselves who invest in household durables and housing to generate a desired flow of services according to a production function using household capital stock accumulated by previous investment. The

[4] This has the undesirable effect of imposing unitary income elasticities, a restriction usually rejected by data. Moreover, in the preliminary version of the model presented here, the elasticities of substitution are assumed to be unity. In future work we plan to replace this specification with one derived from the linear expenditure system, to allow income elasticities to differ from 1.

household is assumed to maximize utility from the flow of services of durable stock by choosing an investment stream subject to quadratic costs of adjustment. As for the firm decision on optimal investment, the result is an investment function depending on the shadow price of capital.

2.3 Government

We take each region's real government spending on goods and services as exogenous and assume that it is allocated among final goods, capital and labour services in fixed proportions, which we set to 1995 values. Total government outlays include purchases of goods and services plus interest payments on government debt, investment tax credits and transfers to households. Government revenue comes from corporate and personal income taxes, sales taxes, and the issuing of government bonds.

We assume that agents will not hold government bonds unless they expect the bonds to be paid off eventually. Therefore, the government is subject to an intertemporal budget constraint that the present value of spending be restricted by the present value of future tax collections from all sources less the initial stock of existing government debt.

The implication of such a constraint is that a government running a budget deficit today must run an appropriate budget surplus at some time in the future; otherwise, the government will be unable to pay interest on the debt and agents will not be willing to hold it. To ensure that the intertemporal budget constraint holds at all points in time, we assume that the government levies a lump-sum tax in each period equal to the value of interest payments on the outstanding debt.[5] In effect, therefore, any increase in government debt is financed by consoles, and future taxes are raised sufficiently to accommodate the increased interest costs. Thus, any increase in the debt will be matched by an equal present-value increase in future budget surpluses.[6]

2.4 Financial markets and the balance of payments

A key feature of the G-Cubed class of models is the integration of financial markets with the real side of the global economy. There are a variety of assets available within each region, including domestic money, government bonds, equity and foreign debt. Each asset represents a claim on a real activity. Money is required for transactions and therefore represents a claim on purchasing power. Government bonds are a claim on the future tax collections of governments. Equity is a claim on the future dividend stream of firms. Foreign debt is a claim on the future export receipts of the debtor countries. The prices of financial assets therefore contain information about the expected future real outcomes in the economy and are used by agents in undertaking real economic activities such as investment and consumption decisions.

The 12 regions in the model are linked by flows of goods and assets. Flows of goods are

[5] In the model the tax is actually levied on the difference between interest payments on the debt and what interest payments would have been if the debt had remained at its base-case level. The remainder—interest payment on the base-case debt—is financed by ordinary taxes.

[6] Other fiscal closure rules are possible, such as requiring the ratio of government debt to GDP to be unchanged in the long run. These closures have interesting implications but are beyond the scope of this paper.

determined by the import demands of households, firms and governments. These demands can be summarized in a set of bilateral trade matrices, which give the flows of each good between exporting and importing countries. There is a 12 × 12 trade matrix for each of the 12 goods.

Trade imbalances are financed by flows of assets between regions. We assume that asset markets are perfectly integrated across all regions except for the "rest of the world". With free mobility of capital, expected returns on loans denominated in currencies of various regions must be equalized from period to period according to a set of interest arbitrage relations. While we allow for exogenous risk premium in the calibration of the model, there is no allowance for endogenous risk premia on the assets of alternative currencies when shocking the model.

Determining initial net asset positions, and hence base-case international capital flows, is nontrivial. We assume that capital flows are composed of portfolio investment, direct investment and other capital flows. These various capital flows are perfectly substitutable *ex ante*, adjusting to the expected rates of return across economies and across sectors. Within an economy, the expected returns to each type of asset (i.e. bonds of all maturities, equity for each sector) are arbitraged, taking into account the costs of adjusting physical capital stock and allowing for exogenous risk premium. Because physical capital is costly to adjust, any inflow of financial capital that is invested in physical capital (i.e. direct investment) will also be costly to shift once it is in place. The decision to invest in physical assets is based on expected rates of return. However, if there is an unanticipated shock, then *ex post* returns could vary significantly. Total net capital flows for each economy in which there are open capital markets are equal to the current account position of that country. The sum of global net flows of capital are constrained to zero.

We treat the "rest of the world" differently from other regions in a more abbreviated form. We assume that the "rest of the world" is subject to an exogenous balance of payments constraint determined by the exogenous amount the world is willing to lend to this region.

2.5 Labour markets

We assume that labour is perfectly mobile among sectors within each region but is immobile among regions. Thus, within each region nominal wages will be equal across sectors. The nominal wage is assumed to adjust according to labour market institutions in different countries. In the United States, for example, wages adjust slowly according to an overlapping-contracts model where nominal wages are set on the basis of current and expected inflation and on economy-wide labour demand relative to labour supply. In the long run labour supply is given by the exogenous rate of population growth, but in the shortrun the hours worked can fluctuate depending on the demand for labour. For a given nominal wage, the sectoral demand for labour will determine short-run employment in each industry, and thus economy-wide unemployment will be the difference between the overall supply and the sum of sectoral demand for labour.

G-Cubed (Agriculture) is still in the process of development, but it is already a large model. In its current form, it contains over 9,000 equations and 175 intertemporal costate variables. None the less, it can be solved using software developed for a personal computer outlined in McKibbin and Wilcoxen (1992). A detailed algebraic description of the model and a complete list of variables and equations can be obtained from the authors upon request.

3. Baseline generation and simulation design

One of the important features of the Asian financial crisis is a jump in the perceived risk of investing in the affected economies. Therefore, we follow the approach in McKibbin (1998) by modelling the crisis as a loss in confidence in each of the affected countries. The loss of confidence is represented by an exogenous increase of the perceived risk of investing in the crisis-affected countries. The method of how those risk shocks are determined is described below.

Before presenting how this is done, we first outline how the baseline was generated without shocks to risk. The model is first solved from 1996 to 2070 to generate a model baseline based on a range of assumptions.[7] These assumptions include population growth by country (based on World Bank projections), and sectoral productivity growth by country and by sector (based on a technology catch-up model developed by Bagnoli *et al*., 1996), as well as assumptions about tariff rates, tax rates and a range of other fiscal and monetary policy variables.

Given all of the exogenous assumptions and initial conditions, the full rational expectations solution of the model is found using a numerical technique outlined in Appendix C of McKibbin and Sachs (1991). Without additional intervention, this initial model solution will not generate the actual outcomes for the first year of simulation, because a range of forward-looking variables such as human wealth, exchange rates, stock prices, etc., will be conditioned on the future path of the world economy and there is no reason why they should be equal to the observed values for the initial year. The next step in the baseline generation is to calculate a vector of constants for all equations in the model such that the solution of the model in the base year (1996) is exactly equal to the observed data for that year. It is important to stress that in no way are we assuming that 1996 is a steady-state solution of the model. It clearly cannot be. What we are imposing is that the 1996 database is on the unique stable path of the model in which all variables are moving towards a steady state in the distant future.

In the baseline we calculate a constant value for risk premium such that the exchange rate in each region, converted into nominal terms using the appropriate price deflators in 1996, is equal to the observed nominal exchange rate. In the simulation, a rise in the risk premium is assumed to last for three years in each of the ASEAN economies and Korea before returning to the baseline. The values of the risk shock are selected such that the model-generated changes in nominal exchange rates are equal to the observed changes in nominal exchange rates in those affected economies as of January 1998.

In addition to the rise in risk, it is assumed that there is an across-the-board decline in productivity in countries experiencing the risk shock, in order to capture the impact of the financial crisis on domestic production. The time profile and extent of the shocks are presented in Table 2.

4. Simulation results

Simulation results of major macro variables are shown in Tables 3(a)–3(c). For presentation purposes, regions in the model are grouped into two groups: (1) those directly affected by the

[7] A long period is used so that expectation of the future evolution of the world economy is not affected by the end-point of the simulation period.

TABLE 2
TIME PROFILE FOR THE SIMULATION SHOCKS[a]

Country/variable	1998	1999	2000	After 2000
ASEAN				
Risk	20	20	10	0
Productivity	−6	−4	−2	0
Korea				
Risk	20	20	10	0
Productivity	−6	−4	−2	0

[a]Percentage changes from baseline.

TABLE 3(a)
IMPACT OF THE ASIAN FINANCIAL CRISIS ON THE WORLD: MACRO INDICATORS[a]

Regions	Affected countries' changes as share of world				World total (after adjustments)			
	1998	1999	2000	2005	1998	1999	2000	2005
Real GDP	−0.3	−0.5	−0.3	0.0	−0.4	−0.4	−0.2	−0.1
Real GNP	−0.3	−0.5	−0.3	0.0	−0.4	−0.4	−0.2	−0.1
HH wealth[b]	−1.7	−1.3	−0.6	0.1	−0.7	−0.7	−0.4	0.0
HH current income	−1.1	−1.3	−0.8	0.0	−0.4	−0.5	−0.3	−0.1
Private consumption	−1.0	−1.1	−0.7	0.1	−0.4	−0.5	−0.3	−0.1
Total investment	−1.9	−1.3	−0.4	0.2	0.0	0.0	−0.2	−0.1
Total imports	0.3	−0.1	−0.2	−0.2	−1.4	−1.0	−0.5	0.0
Total exports	2.2	1.4	0.3	−0.4	−0.3	−0.4	−0.3	0.0

[a]Percentage changes from baseline.
[b]HH wealth includes expected future income plus financial holdings, including equity, bonds, foreign assets and real money.

crisis and neighbouring Asian countries, and (2) major industrial countries.[8] All results are expressed as percentage deviations from baseline except where noted.

Table 3(b) contains macroeconomic impacts of the crisis on the affected countries—ASEAN and Korea as well as neighbouring Asian countries. The rise in risk and fall in productivity lead to an outflow of financial capital from the crisis countries. This outflow of capital depreciates the nominal and real exchange rates by around 60% and 30%, respectively, through 1998 in both ASEAN and Korea. The real exchange rates recover over time, reflecting the assumed restoration of confidence in each economy. The outflow of capital also leads to a sharp rise in real interest rates in the crisis economies and a general deflation of asset prices. The rise in real interest rates, the sharp decline in total wealth and the reduction in current and expected future incomes lead to a sharp drop in domestic demand. Consumption falls by about 35% in ASEAN and Korea throughout 1999. Investment also falls by about 40% in ASEAN and 25% in Korea in 1998. This sharp contraction in economic activity also results from the large capital losses experienced by

[8] The results for Mexico and the Rest of the World are not reported because of space limitations, but are available upon request.

TABLE 3(b)

IMPACT OF THE ASIAN FINANCIAL CRISIS ON MAJOR AFFECTED AND NEIGHBOURING ASIAN COUNTRIES: MACRO INDICATORS[a]

	ASEAN				Korea				Japan				Taiwan				China[d]			
	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005
Real GDP	−7.5	−13.0	−10.9	−1.5	−9.2	−14.1	−8.7	0.2	0.3	0.0	0.0	0.0	−0.3	0.0	−0.1	0.0	−0.2	0.3	0.2	0.0
Real GNP	−9.8	−14.2	−10.5	−0.4	−9.9	−14.4	−8.4	0.8	0.4	0.0	0.0	0.0	0.2	0.3	−0.1	−0.1	−0.1	0.3	0.2	0.0
Private consumption	−34.3	−38.4	−25.4	1.6	−32.3	−35.5	−18.7	3.3	0.0	−0.4	−0.3	−0.2	2.8	2.1	0.6	−0.5	2.6	3.0	1.6	−0.4
Total investment	−43.4	−28.3	−8.4	3.7	−26.4	−18.4	−4.4	2.0	−1.6	−0.2	0.2	0.0	4.7	2.3	0.0	−0.4	4.7	2.3	0.0	−0.4
Total imports	4.0	−0.2	−2.8	−2.7	4.5	−1.8	−3.5	−1.5	0.9	0.3	0.2	0.3	−1.5	−0.6	−0.2	0.3	−2.0	−1.1	−0.3	0.4
Total exports	22.5	14.4	3.8	−4.6	21.7	12.9	2.8	−3.2	2.7	1.0	0.4	0.3	−2.4	−1.4	−0.3	0.5	−4.5	−3.0	−1.1	0.7
Balance of trade[b]	18.0	15.7	7.2	−1.6	16.8	15.0	5.9	−1.4	0.4	0.2	0.1	0.0	−1.6	−1.2	−0.3	0.3	−0.9	−0.7	−0.3	0.1
Real interest[c]	8.6	6.3	2.0	−0.1	6.6	6.0	2.9	−0.1	1.1	0.3	0.0	0.0	−1.1	−1.1	−0.6	0.0	−1.0	−0.7	−0.3	0.0
Inflation rate[c]	20.4	18.4	10.8	1.7	19.2	17.3	6.8	1.0	0.3	0.1	0.0	0.0	−0.6	−0.4	0.0	−0.1	−0.6	−0.3	0.0	0.0
Real exchange rate	−29.4	−18.6	−5.4	5.1	−30.0	−17.2	−3.6	4.2	−9.4	−5.1	−2.0	0.2	−1.2	−1.5	−1.0	−0.3	−1.0	−0.6	−0.4	−0.3
Nominal exchange rate	−60.5	−47.9	−23.1	4.1	−59.8	−45.1	−15.8	5.0	−10.1	−5.8	−2.2	0.3	−2.0	−1.1	−0.9	−0.3	−0.2	0.1	−0.1	−0.3
Real effective exch. rate	−25.8	−16.7	−4.7	5.3	−23.5	−13.3	−2.3	3.7	−1.3	−0.1	−0.5	−1.0	6.8	3.7	0.8	−1.2	8.9	5.3	1.5	−1.3

[a]Percentage changes from baseline.
[b]Percentage of GDP changes from baseline.
[c]Percentage point changes.
[d]China and Hong Kong were aggregated into one region in the model in order to reduce the model's dimensions. Because China's economy is much bigger than that of Hong Kong, simulation results reported here are heavily weighted by China.

TABLE 3(c)

IMPACT OF THE ASIAN FINANCIAL CRISIS ON MAJOR INDUSTRIAL COUNTRIES: MACRO INDICATORS[a]

	United States				Canada				EU12				Australia				Other OECD			
	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005
Real GDP	−0.1	0.1	0.1	−0.1	−0.2	0.2	0.1	−0.1	−0.2	0.1	0.2	−0.1	0.0	0.2	0.1	−0.1	−0.2	0.2	0.2	−0.1
Real GNP	−0.1	0.1	0.1	−0.1	−0.1	0.2	0.1	−0.2	−0.3	0.0	0.1	−0.1	0.0	0.3	0.1	−0.2	−0.3	0.1	0.1	−0.2
Private consumption	0.6	0.7	0.5	−0.1	1.2	1.3	0.6	−0.4	0.6	0.8	0.6	−0.2	1.3	1.4	0.6	−0.4	0.8	1.0	0.6	−0.4
Total investment	3.2	1.6	0.1	−0.4	3.2	1.9	0.2	−0.3	3.4	2.0	0.4	−0.3	3.5	2.1	0.2	−0.3	3.7	2.4	0.4	−0.5
Total imports	−2.6	−1.5	−0.5	0.2	−0.8	−0.4	−0.1	0.1	−2.5	−1.3	−0.4	0.3	−1.3	−0.5	−0.1	0.2	−1.3	−0.7	−0.2	0.1
Total exports	−6.3	−4.0	−1.5	0.4	−3.0	−1.9	−0.6	0.4	−3.4	−2.1	−0.7	0.4	−4.3	−3.0	−1.2	0.4	−3.4	−2.1	−0.8	0.4
Balance of trade[b]	−0.2	−0.2	−0.1	0.0	−1.0	−0.7	−0.2	0.2	−0.3	−0.3	−0.3	0.1	−0.7	−0.6	−0.3	0.1	−0.6	−0.5	−0.2	0.1
Real interest[c]	−0.6	−0.5	−0.2	0.0	−0.9	−0.7	−0.3	0.0	−1.0	−0.9	−0.5	0.0	−0.8	−0.8	−0.4	0.0	−1.0	−0.9	−0.5	0.0
Inflation rate[c]	−0.4	−0.3	−0.1	0.1	−0.6	−0.5	0.1	0.1	−0.4	−0.5	−0.2	0.0	−0.6	−0.5	0.5	0.1	−0.8	−0.7	−0.2	0.2
Real exchange rate					−0.8	−0.6	−0.4	−0.2	−1.2	−0.8	−0.4	−0.1	−0.9	−0.7	−0.5	−0.3	−1.0	−0.6	−0.3	−0.1
Nominal exchange rate					−0.5	−0.3	−0.4	−0.3	−1.2	−0.7	−0.2	0.0	−0.5	−0.5	−0.6	−0.4	−0.7	−0.3	−0.1	−0.3
Real effective exch. rate	7.8	4.6	1.6	−0.6	0.9	0.4	0.0	−0.4	7.1	4.1	1.2	−0.9	5.6	3.2	0.8	−0.9	1.2	0.8	0.3	−0.2

[a]Percentage changes from baseline.
[b]Percentage of GDP changes from baseline.
[c]Percentage point changes.

these economies. In particular, the fixity of physical capital implies a significant reduction in capital use, given the large increase in the cost of capital in the crisis economies.

Despite the large contraction in domestic demand, gross domestic product (GDP) is not hit quite so badly because of the adjustment in exports. The sharp depreciation in the nominal and real exchange rates increases the external demand for local products, both in countries unaffected by the crisis and in those modestly affected. This export surge (note that the change in exports is shown in real terms and not in US$) is consistent with the change in the balance of payments, reflecting a capital outflow. With recovery in most of the Asian economies, apart from Indonesia, Asian exports have increased significantly in the past two years. The ratio of current account to GDP in Thailand, for example, was −8% in 1997; this was turned around into a surplus of 11% in 1998.

The impact on ASEAN and Korea is large. However, the impact on the world as a whole is quite small because of the small size of the affected economies. The reduction of economic activity (primarily consumption and investment) in those affected countries is only a small share of the world total (panel 2 of Table 3(a)); therefore, the crisis overall causes global GDP and GNP growth rates to slow down only slightly, by about 0.3%–0.4% (panel 3 of Table 3(a)). However, there are important adjustments in the global economy in response to the crisis in Asia.

First, there is a sharp redirection of international financial capital flows and a gradual relocation of production capital towards industrial countries. In the early 1990s, there were huge financial capital flows towards emerging markets from capital-abundant industrial countries looking for higher returns. The average capital inflow into emerging markets during 1990–6 was $148 billion annually. Developing countries in Asia attracted more than half of this inflow, with a peak of $102 billion in 1996 (IMF, 1998). As risk increased considerably in the crisis countries, investors lost confidence, causing financial capital to seek "safe havens" in industrial countries, especially the United States.[9] The redirection of financial capital towards developed countries reduces real interest rates in almost all of the industrial countries except Japan, thereby stimulating total investment and private consumption (Tables 3(b) and 3(c)) in those economies. Total investment rises by more than 3% in most of the unaffected economies. The net impact on those economies depends on whether the reduction in exports is more or less important than the growth in investment spending resulting from lower real interest rates. Since GDP is a measure of value added by domestically located factors of production, the relocation of physical capital resulting from higher investment may increase aggregate production and hence GDP growth rate in the unaffected economies. Despite this capital relocation effect, residents in countries receiving capital will earn a lower rate of return from their capital than they would have earned in the pre-crisis high-return Asian economies.

Second, there is a realignment of each economy's international competitiveness through adjustments in each country's real effective exchange rate (REER). The dramatic depreciation of currency in the crisis economies alters multilateral trade-weighted exchange rates and international competitiveness both in Asia and around the globe. However, the depreciation in real effective terms is much smaller than in nominal terms (25% versus 60%) because competitiveness gains from currency depreciation are partially offset by higher domestic inflation in these affected countries (about 20% according to the simulation results). It is interesting to note that the rates of appreciation in real effective terms for the

[9] Based on recent IMF projection, net capital inflows to the developing countries of Asia are projected at only $1.5 billion in 1998.

United States and Australia are higher than for other OECD countries because of their more significant trade ties (and therefore higher weights in the index) with these affected Asian countries. The real effective appreciation rates for Taiwan, China and Hong Kong are even higher, reflecting the competitive pressure on these economies because their products compete more directly with the affected Asian countries in third markets, especially developed markets. However, the magnitude of real appreciation is quite modest—less than 9%, consistent with recent estimates by Noland *et al*. (1998).

Third, there are substantial adjustments of external positions by almost all economies in the world, especially for those countries in crisis and for countries that have important trade and financial links with them. As discussed earlier, the sharp declines in private capital inflows and the dramatic increase in interest payments for outstanding debt will require substantial adjustments in the external positions of the affected Asian countries. With the improvements in competitiveness associated with the declines in currency values, the crisis countries will reduce their demand for imports and expand exports. This will force an improvement in their external position, with production resources shifting towards the export sector to generate the trade surpluses necessary to serve their international debt. Industrial countries, except Japan, are expected to have worsening trade balances. The EU and Canada reduce their trade surplus by 0.3% and 1% of GDP, respectively, while the US trade deficit increases by about 0.2% of GDP. The worsening trade balance in industrial countries for several years is necessary for recovery in the Asian crisis economies and reflects the redistribution of global demand through international trade, which occurs through adjustment in real exchange rates.

Finally, global supply and demand conditions are changed significantly for many important primary commodities. For example, Asian developing countries accounted for about two-thirds of the increased world consumption of petroleum products in 1992–6, and Korea and ASEAN-4 accounted for about one-half of this increase. The share of these countries in world consumption rose from 5% to 6.5% during this period (IMF, 1998). The currency crisis reduced construction activities in the affected economies, and induced higher energy import costs in terms of national currencies, implying less available credit to finance imports, and causing a sharp reduction in energy demand. As shown by the simulation results, total energy demand falls by more than 40% in both Korea and ASEAN countries, thus reducing the price of energy worldwide during 1998 and 1999, as shown in Figure 2.

In all, despite a fall in exports by most countries, the decline in real interest rates and the lower world prices of intermediate inputs in the short run have an offsetting and stimulative effect on economic growth outside those countries in crisis.[10]

What are the implications of these global adjustments induced by the crisis in Asia for the US economy, especially for its food and agricultural sectors? As shown in Table 3(c), after a small fall in US GDP in 1998, the relocation of capital increases production in the United States for a number of years. Importantly, the structure of the US economy changes as well. Table 4(a) shows that the fall in demand in Asia reduces US exports across all sectors, with agricultural industries falling more than non-agricultural sectors. This effect is due to higher dependence on global and Asian markets of US agricultural products than other US products

[10] The logical implication from our simulation results for the fact that economic recovery in most of crisis-affected Asian countries is under way, is that its impact on the world economy will be the opposite of what is described here. As investors rebuild confidence, capital will flow back to these economies, raising real interest rates in the industrial countries, especially the United States. In the meantime, economic recovery in those countries will increase their demand for energy and intermediate inputs, driving up world prices for such products. However, a thorough analysis needs another project and is beyond the scope of this paper.

TABLE 4(a)

IMPACT OF THE ASIAN FINANCIAL CRISIS AND GLOBAL ADJUSTMENTS ON THE STRUCTURE OF THE US ECONOMY[a]

	Production				Consumption				Exports				Imports				Exports/ production		Imports/ absorption	
	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	Total	Asia	Total	Asia
Food grains	−5.98	−4.04	−1.55	0.49	2.60	1.27	1.25	−1.16	−6.54	−4.63	−1.98	0.51	0.00	−3.57	0.00	0.00	40.27	12.24	4.68	1.00
Feed grains	−2.02	−1.16	−0.35	0.05	0.00	3.85	0.00	0.00	−6.68	−4.57	−1.92	0.32	−4.35	0.00	0.00	0.00	16.32	6.98	0.94	0.00
Non-grain crops	−2.12	−1.08	−0.28	0.07	3.09	2.27	1.06	−0.39	−5.30	−3.30	−1.27	0.40	0.58	0.33	0.12	−0.06	22.30	9.15	17.24	2.30
Livestock products	−0.20	0.14	0.23	−0.05	1.01	1.10	0.69	−0.16	−9.36	−6.72	−2.75	0.69	0.58	0.57	0.32	0.08	3.37	1.80	2.53	0.05
Processed food	0.31	0.51	0.44	−0.04	1.29	1.22	0.73	−0.18	−5.71	−3.80	−1.44	0.50	2.51	1.61	0.37	−0.59	5.92	1.78	4.85	0.83
Agricultural total	−0.33	0.06	0.22	−0.02	1.36	1.27	0.75	−0.19	−6.25	−4.18	−1.67	0.47	0.89	0.55	0.18	−0.14	7.72	2.94	4.88	0.63
Non-agricultural total	0.06	0.21	0.13	−0.07	0.72	0.93	0.63	−0.16	−4.99	−3.19	−1.20	0.32	2.85	1.71	0.51	−0.26	5.45	1.37	6.32	2.20
Total	0.03	0.20	0.14	−0.07	0.78	0.97	0.64	−0.17	−5.18	−3.34	−1.27	0.34	2.56	1.53	0.46	−0.24	5.60	1.47	6.23	2.10

[a]Percentage changes from baseline.

TABLE 4(b)

IMPACT OF THE ASIAN FINANCIAL CRISIS AND GLOBAL ADJUSTMENTS ON THE INPUT STRUCTURE OF THE US ECONOMY[a]

	Investment				Capital stock				Labour				Energy				Material			
	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005	1998	1999	2000	2005
Food grains	6.4	3.9	1.2	0.1	0.0	0.2	0.3	0.1	−6.4	−3.8	−1.8	0.0	−6.3	−4.6	−1.5	1.3	−5.6	−3.7	−1.5	0.4
Feed grains	3.7	1.5	−0.3	0.0	0.0	0.1	0.1	0.0	−2.6	−1.4	−0.5	0.0	−2.5	−0.8	0.0	0.0	−1.9	−1.1	−0.3	0.0
Non-grain crops	0.5	−0.9	−1.4	0.1	0.0	0.0	0.0	−0.1	−3.3	−1.6	−0.5	0.0	−2.3	−1.5	−0.7	0.0	−2.6	−1.2	−0.3	0.1
Livestock products	1.5	0.9	0.2	0.4	0.0	0.1	0.1	0.0	−0.9	−0.2	0.1	0.0	−0.3	0.0	0.0	0.0	−0.1	0.2	0.2	−0.1
Processed food	5.5	8.1	5.3	0.2	0.0	0.2	0.4	0.2	−0.5	0.1	0.3	0.0	0.0	0.4	0.4	0.0	0.7	0.8	0.5	−0.1
Agricultural total	2.8	1.9	0.6	0.1	0.0	0.1	0.2	0.1	−1.3	−0.4	0.0	0.0	−0.9	−0.3	0.0	0.1	−0.1	0.2	0.3	−0.1
Non-agricultural total	1.8	1.5	0.6	0.2	0.0	0.1	0.2	0.0	−0.2	0.1	0.1	0.0	0.1	0.2	0.1	0.0	0.4	0.4	0.1	−0.1
Production capital	9.6	−1.7	−5.9	0.6	0.0	0.7	0.5	−0.3	1.8	0.8	−0.2	−0.2	2.2	0.9	−0.2	−0.1	2.8	1.4	0.0	−0.3
Consumer durable	2.7	1.0	−0.4	−0.2	0.0	0.3	0.4	0.0												
Total	3.2	1.6	0.1	−0.4	0.0	0.2	0.2	0.0	−0.2	0.1	0.1	−0.1	0.1	0.2	0.1	0.0	0.8	0.6	0.1	−0.1

[a]Percentage changes from baseline.

(Table 4(a), last panel). The impact on exports is relatively similar across all US agriculture sectors—a fall of around 6% during 1998, except for a large drop in livestock products (a fall of more than 9%). This fall in exports across the board is offset by a rise in consumption (Table 4(a), panel 3) and private investment (Table 4(b), panel 2) in the US economy resulting from lower consumer prices and lower real interest rates. Consumption increases in all sectors, with non-grain crops, food grain, textiles (Table 4(a)), and consumer durables such as housing and automobiles (Table 4(b)) increasing the most. The increasing consumption of textiles reflects the cheaper imports from Asian countries arising from competitive devaluation. The boom in the consumer durables sector is mainly a result of lower real interest rates, while the increased demand for agricultural products is the result of increased domestic demand more than offsetting declines in exports. This change in the structure of the US farm sector from exports to domestic demand is clear in the second panel of Table 4(a), which shows that the effects of the crisis on US agricultural production are quite different according to sector. Output of those sectors with the highest trade exposure—food grains (more than 40% of production exported, 12% going to the Asian market: Table 4(a) last panel)—declined the most, about 6% in 1998. Feed grains and non-grain crops—15%–25% of production exported and less than 10% to Asia—decline modestly, about 2%. And for livestock products and processed food—the least dependent on trade, with less than 6% of production exported and less than 2% to Asia—output increases in response to strong domestic demand stimulated by strong investment spending and lower consumer prices, despite a strong increase in imports resulting from lower-price exports from Asia. (Imports of processed food increase by 2.5% in 1998—Table 4(a), panel 5.) As indicated by the simulation results, the stock of physical capital increases in almost all sectors except non-grain crops and the durable goods sector (panel 3 of Table 4(b)), owing to increases in investment (panel 2 of Table 4(b)), with production capital and consumer durable sectors increasing the most. Increases in investment and the capital stock drive the production expansion in domestic-oriented sectors. This is supported by the induced strong domestic demand for agricultural products, especially processed food.

Thus, within the US food and agriculture industry, we see different responses to the Asian crisis. As expected, the more exposed the commodity is to export markets, the greater is the impact of the Asia crisis. The major additional insight from the model used here is the switch towards domestic demand driven by the changes in international capital flows and lower prices for intermediate inputs induced by the global adjustments from the Asian crisis.

What do these global adjustments imply for US food and agricultural producers? Obviously, there is a drop in farm revenue because of declining export prices and shrinking export demand from Asia. However, as shown in Figure 4, there is an increase in Tobin's q, the shadow price of sector-specific capital, implying reduced capital cost or increased unit value for investment. This explains the seemingly contradictory results observed in Tables 4(a) and 4(b). Production decreases in food grain, feed grain and non-grain crop sectors 4(a), but investment in those sectors goes up. The key reason here is our assumption of producers' expectations in the simulations 4(b). With an expectation that the Asian financial crisis is a temporary shock, producers will take advantage of low capital costs to replace/upgrade machinery and equipment in the short run, in order to increase their production capacity to meet the anticipated higher demand in the longer run. There are also declining costs of intermediate inputs in agricultural production because of lower real interest rates, cheaper import prices and reduced demand for intermediate inputs resulting from the economic slowdown in Asia (Figures 2–4). The changes in relative input prices induce substitution

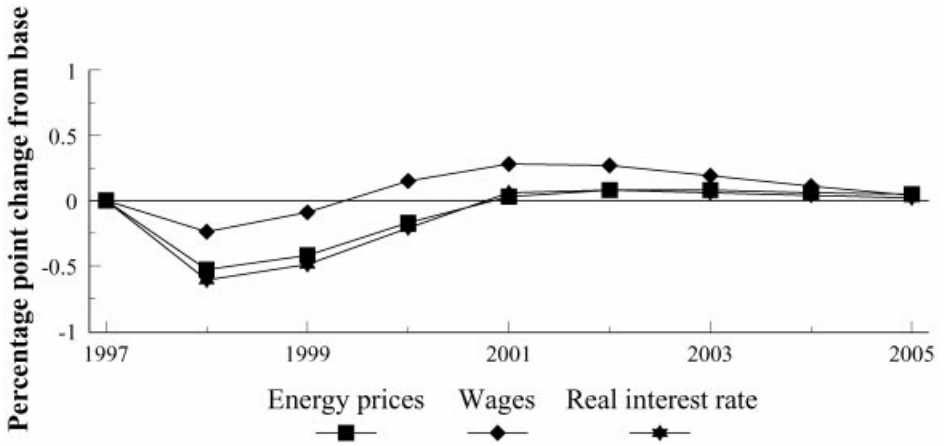

FIGURE 2. Changes in average wages, real interest rate and price of energy inputs in the United States, 1997–2005

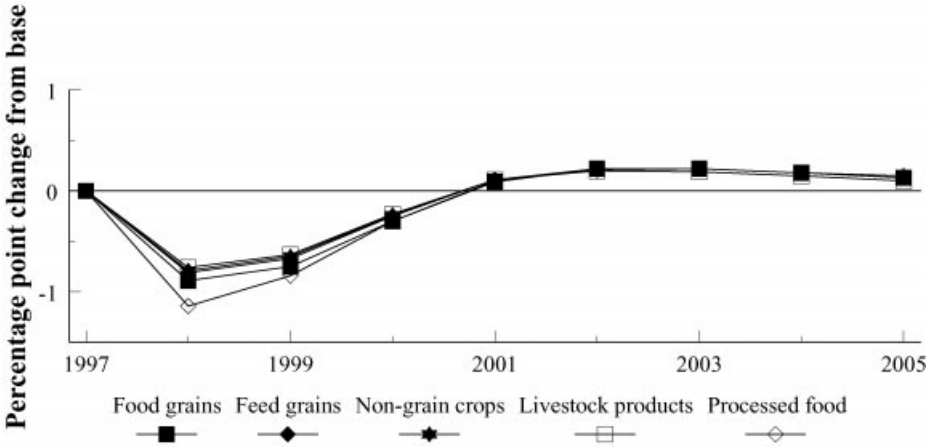

FIGURE 3. Changes in prices of material inputs in US farm sector, 1997–2005

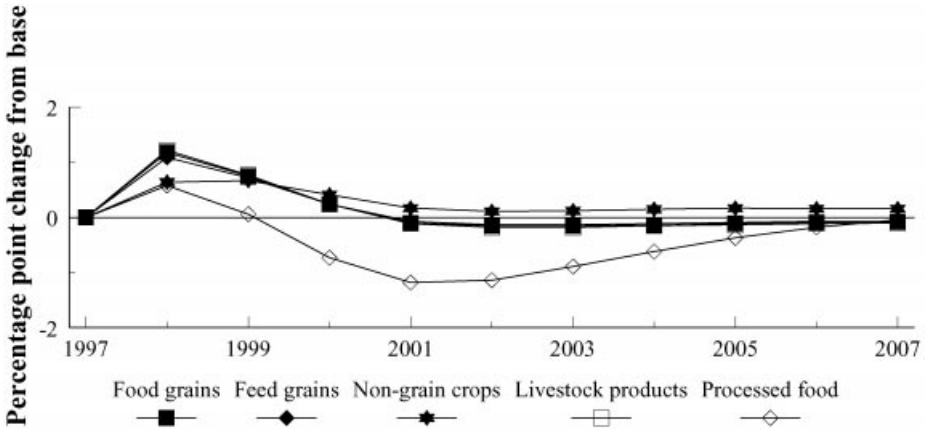

FIGURE 4. Changes in shadow prices of capital stock in US agriculture, 1997–2007

among production factors, causing changes in the input mix across agricultural sectors, as shown in Table 4(b).

Despite the stimulating effects to the US economy of lower real interest rates and intermediate input prices, the simulation results also show clearly that the Asia financial crisis represents a setback for the world economy. Global real GDP declines 0.4% in 1998 and 1999. It is interesting to note that the reduction of total world GDP is smaller than for the affected countries, implying a rise in GDP in the rest of the world. However, if more Asian countries, especially Japan, become more embroiled in the crisis, a decline in world GDP exceeding that for the affected countries will be observed.[11] The rest of the world may no longer be able to buffer the negative shock of a financial crisis when it spreads to other parts of Asia, particularly a large economy like Japan.

5. Conclusions and directions for future research

Our simulation results show that the crisis in Asia will not only reduce US exports but will also reduce global real interest rates and the cost of intermediate inputs of production within the US economy. Lower capital costs and intermediate prices will stimulate US domestic economic activity, especially in interest-sensitive sectors. This stimulus to domestic demand may or may not offset the negative impacts of a decline in exports, depending on the relative reliance of each sector on domestic US demand versus dependence on Asian markets. The redirection of financial capital flows away from Asia to the United States and other developed markets stimulates investment in the US economy, especially in those sectors relying most heavily on the domestic market, such as processed food, while export-oriented sectors such as food grains are more negatively affected by the crisis.

The simulation results provide useful insights in understanding the offsetting effects of the Asian crisis on US agriculture. However, since the model we used is a stylized representation of the US and world economies, the results should not be interpreted as forecasts, but rather as indicative of the potential impacts of the crisis. Because the model is still under development, only one representative household is defined for each region. Therefore, we are not able to make conclusions about the net welfare effects of the Asian financial crisis on US farm households *per se*. This is possible, but requires further research and model development. However, since off-farm income now accounts for more than 80% of average farm household income in the United States, the impact of the Asian crisis on US farm welfare may prove to be limited unless the crisis worsens further. Despite the preliminary nature of the model, results presented in this paper suggest the useful role of the model, particularly in analysing the impact of financial adjustments on global and US agriculture.

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[11] We conducted simulations to verify this point.

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