ECONOMIC NETWORK STRUCTURES, GROWTH AND POVERTY

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ABSTRACT

While investors are advised to diversify in order to manage risk, developing countries are advised instead to liberalise their trade regimes and specialise according to their current comparative advantage. This study uses 67 regions of the GTAP database to investigate the effects of unilateral liberalisation and its impacts on countries' economic structures and the extent to which this affects countries' vulnerability to an economic shock.

While liberalisation resulted in improvements in GDP and welfare on average, there were significant variations. A number of countries experienced contractions in their GPDs and declines in welfare. While there was no evidence of a relationship between the percentage change in GDP and the initial export or output concentration, there was a positive relationship between the percentage change in GDP and the percentage change in export and output concentrations. On average, increases in GDP following liberalisation were associated with increases in concentration in both the export sector and in overall industrial output and also reductions in the fraction of unskilled labour employed by the main export sector. Initial GDP per capita has no significant effect, implying that once concentration measures and the fraction of costs in the main export are accounted for, the per capita income levels of a country show no systematic effects on the percentage change in GDP induced by the liberalisation. For developing countries undergoing unilateral liberalisation, the results imply that they are likely to experience an increase in GDP, but an increase accompanied by more highly concentrated industrial output and exports, and also a lower fraction of main export costs due to unskilled labour.

Following liberalisation, the responses of liberalised and non-liberalised versions of the region's economies to a shock were compared. The rest of the world's productivity in the country's main export was increased by 10%, with the liberalised economies faring marginally worse on average in welfare and terms of trade effects, but slightly better on GDP effects. When the net effects of the initial liberalisation and subsequent technology shock were compared, countries were better off on average if they had liberalised. But this average masked important sectoral differences. Countries specialising in sectors with high proportions of own-commodity inputs in their main export's total cost, such as manufacturing, did best, while those specialising in food tended to suffer welfare declines. Higher levels of export and output concentration also tended to reduce welfare. This suggests that increased concentration does indeed make countries more vulnerable to certain economic shocks. Finally, the economic network structures of the two extreme cases, Tanzania and Vietnam are compared visually as an aid to interpretation.

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1. INTRODUCTION

For the last 30 years, developing countries have been routinely advised to liberalise their trade regimes, on the basis that liberalising will maximize the benefits of their current comparative advantages making them they will be better off. There are certainly costs to trade restrictions, particularly in terms of a potential misallocation of resources, and trade liberalisation can bring significant benefits. But are there also costs and risks associated with the specialisation that liberalisation may induce? Investors are advised to diversify in order to manage risk. Should the same advice apply at a national level to export specialisation? Does excessive specialisation make countries more vulnerable to particular kinds of shocks? For example, does too great a concentration in the export sector, or in industrial output - specialising in too few products - also bring its own risks and costs? If so, then blanket liberalisation may not be optimal if it increases specialisation beyond a certain point.

There have been a number of studies of developing countries' options for specialisation and diversification using a portfolio optimisation approach analogous to that developed in finance by Markowitz (1959). Love (1979) showed that diversification can indeed lower export earnings volatility if the country diversifies into products whose price movements are not strongly correlated with current exports. But if the new products are of lower value, there can be a trade-off between greater stability and lower overall value of export earnings. So diversification offers the potential, but not the guarantee of greater stability and higher earnings if undertaken carefully. Alwang and Sielgel (1994) discussed a similar approach for Malawi, Tanzania and Zimbabwe and Labys and Lord (1990) examined Latin American experiences. Both studies found that the portfolio approach can provide useful guidance to policy makers. Alwang and Siegel (1994, p. 420) emphasised that general equilibrium models can be useful in identifying the real domestic resource costs of different approaches.

Questions of specialisation and diversification rely on an analysis of an economy's structure. The significant structural features of an economy can be analysed by modelling it as a network (or graph) of nodes (economic sectors or industries) connected by directed links weighted by value or volume (flows of funds and resources). The analysis of economies as networks is not new (eg. Snyder & Kick, 1979; Nemeth & Smith, 1985; Smith & White, 1992; Kirman, 1997; Sonis & Hewings, 1998; Sonis *et al.* 1995; Sonis *et al.* 1997), but the possibilities for such analysis have increased dramatically with the advent of faster computers, and the recent surge of developments in network theory (Albert & Barabási, 2002; Newman, 2003; Strogatz, 2001; Watts & Strogatz, 1998). Where once only small

networks, with at most tens of nodes could be analysed, today networks with millions of nodes may be examined. This explosion in computing power has been accompanied by the development of new statistical techniques for summarizing the properties of large networks and complex weighted networks (Barthélemy *et al.* 2005; Newman 2004). It has also produced a burgeoning literature on the characteristics of networks that make them more or less vulnerable to attack or failure (Albert *et al.* 2000; Callaway *et al.* 2000; Crucitti *et al.* 2003, 2004; Gallos *et al.* 2004). Complex dynamic networks may undergo highly nonlinear behaviour such as topological phase transitions (Agiza *et al.* 2003; Derényi *et al.* 2004; Li *et al.* 2004; Palla *et al.* 2004), in which apparently small changes in network structure, such as the loss of a key node, or the forging of a new link, can dramatically affect the network's vulnerability to external shocks. Analysing the network structures of economies can help illuminate the debate on the importance of 'linkages' in the development economics literature, and the threshold effects involved in industrialisation and deindustrialization.

2. METHODOLOGY

This study is the first stage in a broader investigation of the value of recent advances in network theory to economic analysis. As such it concentrates on only certain network features, such as industrial output and export concentration, and illustrates some ways in which network visualisation can be used to compare economies. The objective is to investigate the effects of liberalisation on a country's economic structure, and whether there is any correlation between that structure and the country's vulnerability to particular economic shocks.

Industrial output concentration and export concentration were measured using a modified version of the Herfindahl-Hirschmann index similar to that used by UNCTAD (2003, p. 404). Whereas UNCTAD uses each of the 239 products at the three-digit SITC level to assess export concentration, the present study uses each of the 57 GTAP sectors. The index is calculated as a square root of the sum of the squared ratios of each of the GTAP sectors to total output/exports. The result is then normalized to obtain numeric range from 0 to 1 (maximum concentration):

$$H_j = \frac{\sqrt{\sum_{i=1}^{57}\left(\frac{x_i}{X}\right)^2} - \sqrt{1/57}}{1-\sqrt{1/57}}$$

where, H_j is the country index; x_i is the value of exports of product i; and $X = \sum_{i=1}^{57} x_i$

Export concentrations were calculated using **VXWD (*i, r, s*),** the value of exports of product *i* from region *r* to region *s* valued at world prices. Output concentration was calculated using **VOM(*i,r*)**, the value of output at market prices. In both cases *i* represents the set of 57 traded commodities, since each industry produces one unique commodity and that commodity is produced only by that industry.

The level of aggregation obviously has an effect on the calculation of the concentration index, which begs the question: At what level of aggregation should a concentration index be calculated? The question is unanswerable of course, since the answer must lie at some arbitrary point between broad categories such as 'agriculture' and 'manufacturing' and individual firms' products. The key is to identify 'industries' or 'sectors' which produce reasonably clearly delineated products. Solutions to such subjective definitional problems will inevitably be forced by the availability of data. More detailed data such as the SITC three-digit data used by UNCTAD is probably more accurate in isolation, but they cannot be used readily for policy simulations. GTAP's 57 sector classification is less ideal in terms of the 'accuracy' of the indices, but the GTAP database has the great advantage that it is enormously rich in tracking inter-sectoral and international flows of funds, it has been rigorously checked for consistency across countries, and can be used for sophisticated modelling simulations. For the purposes of this exercise, in which the broad questions of economic structure and liberalisation are being investigated, the relative coarseness of the GTAP sectoral classifications is no great problem. For detailed policy work on a particular country however, more detailed data would be useful.

This study uses version 5.4 of the GTAP database and version 6.2 of the standard GTAP model. The model is implemented using version 8 of GEMPACK (Harrison and Pearson, 1996). The simulations used the Gragg 2-4-6 solution algorithm and the standard GTAP closure, which is a short-run closure, in that supplies of capital are exogenously fixed. A long-run closure such as that developed by Walmsley (1998, 2002), which accounted for ownership of capital, or a dynamic model such as that developed by Ianchovichina and McDougall (2000) would doubtless produce somewhat different results.

3. SIMULATION 1: LIBERALISATION, CONCENTRATION AND WELFARE

To test the effects of liberalisation on export and output concentration and welfare, 67 separate two country-57 sector versions were constructed. The 67 'countries' comprised all 65 separately disaggregated countries apart from Croatia, plus two aggregated regions: the Rest of the Southern African Customs Union, XSC (South Africa, Namibia, Lesotho and Swaziland) and the Rest of the Andean Pact, XAP (Ecuador and Bolivia). Croatia was excluded because the solutions produced anomalous results with extremely low accuracy reports for the solutions.[2] XSC and XAP were included because it was felt that of the aggregated regions, these came closest to representing realistic 'countries'.[3] Each of the 67 versions comprised the country of interest, such as Brazil, and the rest of the world (ROW), and the full 57 separate traded sectors. Each aggregation was then given a liberalisation shock: Tariffs (rTMS), output subsidies (rTO) and export taxes/subsidies (rTXS) were all reduced to zero.

It might have been expected under standard Ricardian theory that liberalisation would result in further specialisation and an increase in concentration. In fact, as Table 1 and Figures 1 to 3 show, there were a wide variety of results. There was indeed an increase in export concentration for 34 out of 67 countries, with a mean increase of 5.78%, but there was also a large standard deviation of 16.23%. The changes ranged from a decrease in concentration of 18.8% (Colombia) to an increase of 78.6% (Vietnam) and 15 countries experienced an increase in export concentration of more than 10%. For output concentration, the mean was still positive, but lower, at 4.55%, but it had a much lower standard deviation, of just 6.98%. As a result, far more countries experienced an increase in output concentration: 58 out of 67. Outcomes ranged from a decrease of 4.80% (Singapore) to an increase of 43.47% (Vietnam).

The average change in GDP was 1.81%, with a large standard deviation of 6.38%, ranging from -7.44 to +39.34. Welfare improved on average by 0.77% of GDP with a standard deviation of 1.30%, ranging from -2.26 % to 8.21%. The GTAP model measures welfare in terms of Equivalent Variation (EV), defined as the amount of money that would have to be

[2] A very large proportion of variable and data figures for Croatia recorded zero accuracy for the tech shock of the liberalised version (introduced in the next section). A *walraslack* variable result of zero reveals that an equilibrium solution has been found and that savings equals investment. All *walraslack* results were checked for all simulations, and this was the only non-zero result, at 0.005.

[3] It should be noted of course, that certain GTAP 'countries' such as the UK, USA and Indonesia are also in fact aggregated regions. The 'USA' for example, includes the United States of America, Puerto Rico, Guam, the US Virgin Islands, the Northern Marianas Islands and American Samoa. In calculating the population figures for GDP per capita used later in the paper, these aggregations were taken into account.

taken away from a consumer before the price changes resulting from a simulation, in order to leave her as well of as she would have been after the price changes. Huff and Hertel (2000, p. 6) define the regional household's EV as the difference between the expenditure required to obtain the new (post-simulation) level of utility at initial prices ($\mathbf{Y_{EV}}$) and the expenditure available initially ($\mathbf{Y}$): $\mathbf{EV = Y_{EV} - Y.}$ In other words, it is "the income change that is *equivalent* to the price change in terms of change in utility" (Dimaranan, 2000). The EV may be broken down to see which of its components had the most influence. In this study, overall welfare change and the change in welfare due to terms of trade effects are used primarily.

The large standard deviations associated with the GDP and welfare results imply that while 'on average' liberalisation led to improvements in GDP and welfare across the 67 region sample, there was also significant variation. Indeed, when change in export concentration is plotted against change in welfare as a percentage of GDP, as in Figure 1, we find countries in all four quadrants. There are countries where both export concentration and welfare increased (NE quadrant, e.g. Vietnam), where concentration increased and welfare declined (NW quadrant, e.g. the Czech Republic), where concentration declined and welfare increased (SE quadrant, e.g. France), and where both concentration and welfare declined (SW quadrant, e.g. Tanzania). The fact that the results show examples of all four types shows the importance of a general equilibrium modelling framework where shocks are transmitted through the system, with sometimes surprising outcomes.

Figure 1: ***Change in export concentration following liberalisation vs change in welfare as a percentage of GDP.***

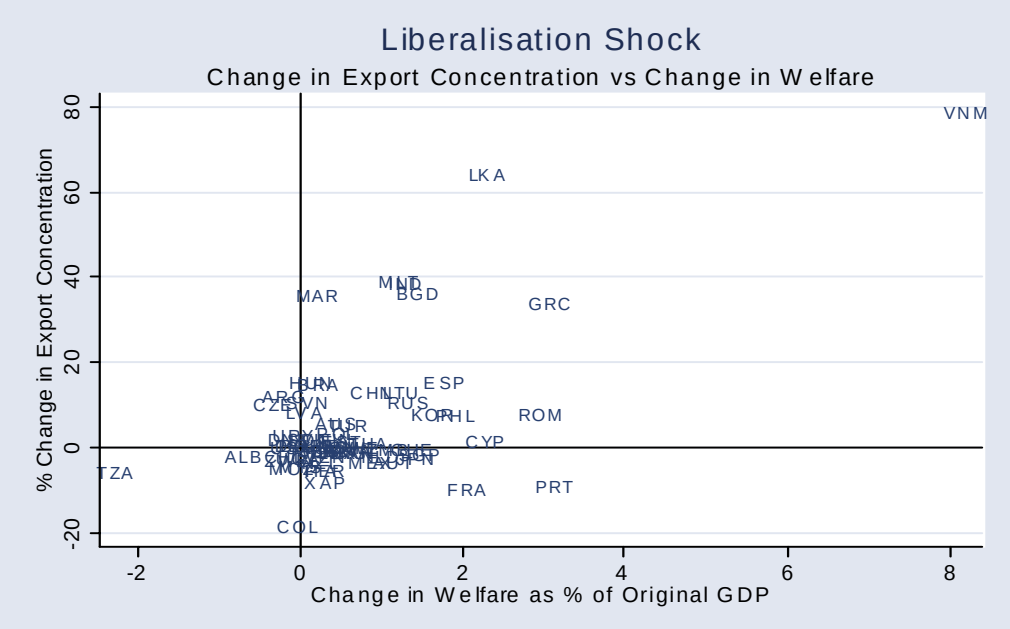


Table 1. Concentrations and Results from Liberalisation Simulations

Country	*Country Code*	*Export Conc. Pre-Lib.*	*% change in export conc.*	*Output Conc. Pre-Lib.*	*% change in output conc.*	*% change in GDP*	*Welfare change (1997 US$m)*	*Welfare change as % of original GDP*
Albania	ALB	0.279	-2.32	0.155	4.371	-5.501	-15.872	-0.695
Argentina	ARG	0.121	12.16	0.072	-0.117	-2.628	-593.790	-0.182
Australia	AUS	0.090	5.42	0.133	2.964	2.474	1,768.386	0.450
Austria	AUT	0.161	-3.41	0.172	1.184	2.306	2,255.173	1.144
Bangladesh	BGD	0.442	36.04	0.116	6.980	8.210	634.646	1.444
Belgium	BEL	0.170	-1.02	0.104	0.882	0.570	850.957	0.368
Botswana	BWA	0.696	-0.97	0.275	-0.714	-1.939	29.107	0.610
Brazil	BRA	0.103	14.70	0.097	1.824	-0.039	1,913.936	0.242
Bulgaria	BGR	0.126	0.39	0.058	-0.001	0.219	3.593	0.037
Canada	CAN	0.160	-1.45	0.097	4.747	-1.078	4,200.922	0.666
Chile	CHL	0.248	-2.28	0.097	2.232	-2.575	-147.042	-0.193
China	CHN	0.173	12.94	0.083	10.069	4.429	7,779.553	0.910
Colombia	COL	0.174	-18.81	0.115	-0.014	-0.525	-7.888	-0.008
Cyprus	CYP	0.372	1.39	0.150	8.435	7.393	176.458	2.293
CzechRep	CZE	0.146	9.93	0.108	1.658	-1.412	-164.025	-0.317
Denmark	DNK	0.150	2.03	0.146	0.180	-0.964	-222.762	-0.135
Estonia	EST	0.098	1.28	0.079	0.134	0.932	18.811	0.518
Finland	FIN	0.229	1.71	0.140	1.335	0.544	527.946	0.452
France	FRA	0.146	-10.02	0.130	3.293	3.385	28,567.197	2.079
Germany	DEU	0.243	0.36	0.164	0.031	-0.967	-1,092.841	-0.053
Greece	GRC	0.182	33.61	0.133	6.546	11.804	3,548.792	3.085
HongKong	HKG	0.360	-1.41	0.257	-1.036	1.725	805.772	0.576
Hungary	HUN	0.155	15.05	0.117	3.198	-0.074	61.341	0.150
India	IND	0.148	38.46	0.073	11.012	13.415	5,268.909	1.318
Indonesia	IDN	0.119	1.83	0.073	5.428	-0.902	341.645	0.164
Ireland	IRL	0.288	0.60	0.122	1.762	0.524	313.831	0.471
Italy	ITA	0.185	-5.35	0.147	-0.545	-0.670	3,096.335	0.275
Japan	JPN	0.294	-2.71	0.136	8.361	6.577	60,976.877	1.433
Korea	KOR	0.232	7.81	0.098	6.715	3.979	7,339.998	1.647
Latvia	LVA	0.165	8.36	0.114	3.102	-0.148	2.184	0.055
Lithuania	LTU	0.128	12.90	0.102	8.371	3.767	97.386	1.251
Luxembourg	LUX	0.175	-1.25	0.106	0.956	0.810	47.724	0.483
Malawi	MWI	0.637	-0.11	0.188	1.883	-2.022	13.330	0.474
Malaysia	MYS	0.396	-4.28	0.151	0.086	-2.408	17.071	0.016
Malta	MLT	0.260	39.06	0.166	18.672	3.903	37.022	1.233
Mexico	MEX	0.227	-3.38	0.102	0.026	2.340	3,355.965	0.863
Morocco	MAR	0.207	35.79	0.119	4.696	0.381	77.425	0.222
Mozambique	MOZ	0.186	-4.79	0.188	2.017	-0.699	-3.826	-0.105
Netherlands	NLD	0.155	-2.15	0.158	1.144	2.022	3,606.903	1.004
NewZealand	NZL	0.131	-3.59	0.116	1.784	-0.639	168.799	0.259
Peru	PER	0.218	-5.39	0.086	2.863	-1.800	201.370	0.310
Philippines	PHL	0.400	7.19	0.102	5.770	11.843	1,509.790	1.927
Poland	POL	0.099	3.09	0.106	6.022	-2.791	580.996	0.467
Portugal	PRT	0.125	-9.30	0.130	2.229	6.575	3,091.755	3.140

Table 1 (cont): ***Concentrations and Results from Liberalisation Simulations***

Country	*Country Code*	*Export Conc. Pre-Lib.*	*% change in export conc.*	*Output Conc. Pre-Lib.*	*% change in output conc.*	*% change in GDP*	*Welfare change (1997 US$m)*	*Welfare change as % of original GDP*
RAndeanPct	XAP	0.250	-8.19	0.081	3.839	-1.093	87.507	0.321
Romania	ROM	0.159	7.81	0.054	22.727	-2.685	1,045.551	2.978
RSthAfCU	XSC	0.195	-0.05	0.117	1.549	-3.874	375.968	0.270
Russia	RUS	0.204	10.40	0.091	13.090	8.239	6,039.520	1.341
Singapore	SGP	0.429	-1.84	0.222	-4.787	4.086	1,179.178	1.478
Slovakia	SVK	0.150	1.88	0.084	1.483	-0.065	14.718	0.085
Slovenia	SVN	0.174	10.47	0.099	6.358	-2.836	17.987	0.106
Spain	ESP	0.144	15.40	0.154	7.181	9.353	9,386.887	1.802
SriLanka	LKA	0.308	63.86	0.127	22.751	13.838	359.034	2.303
Sweden	SWE	0.199	-0.11	0.157	0.350	-0.190	1,583.990	0.696
Switzerland	CHE	0.303	-0.64	0.138	4.440	-3.055	3,512.690	1.408
Taiwan	TWN	0.307	-1.34	0.128	1.073	-1.581	469.820	0.157
Tanzania	TZA	0.190	-5.99	0.113	-0.020	-7.440	-152.817	-2.265
Thailand	THA	0.215	1.06	0.086	9.991	-0.857	1,333.320	0.845
Turkey	TUR	0.144	5.15	0.119	6.467	3.213	1,112.466	0.578
Uganda	UGA	0.565	-2.63	0.204	2.223	-0.794	-0.866	-0.013
UK	GBR	0.154	-0.75	0.140	1.413	0.198	3,039.779	0.236
Uruguay	URY	0.104	2.67	0.092	1.232	-3.747	-12.804	-0.067
USA	USA	0.175	-0.09	0.149	-0.002	-0.970	-7,678.711	-0.097
Venezuela	VEN	0.458	-2.37	0.123	1.639	0.515	254.430	0.304
Vietnam	VNM	0.192	78.61	0.126	43.474	39.338	1,793.585	8.210
Zambia	ZMB	0.521	-0.48	0.098	4.730	4.183	46.073	1.094
Zimbabwe	ZWE	0.229	-3.34	0.107	3.146	-2.762	-12.464	-0.152

Figure 2: ***Change in export concentration following liberalisation vs percentage change in original GDP.***

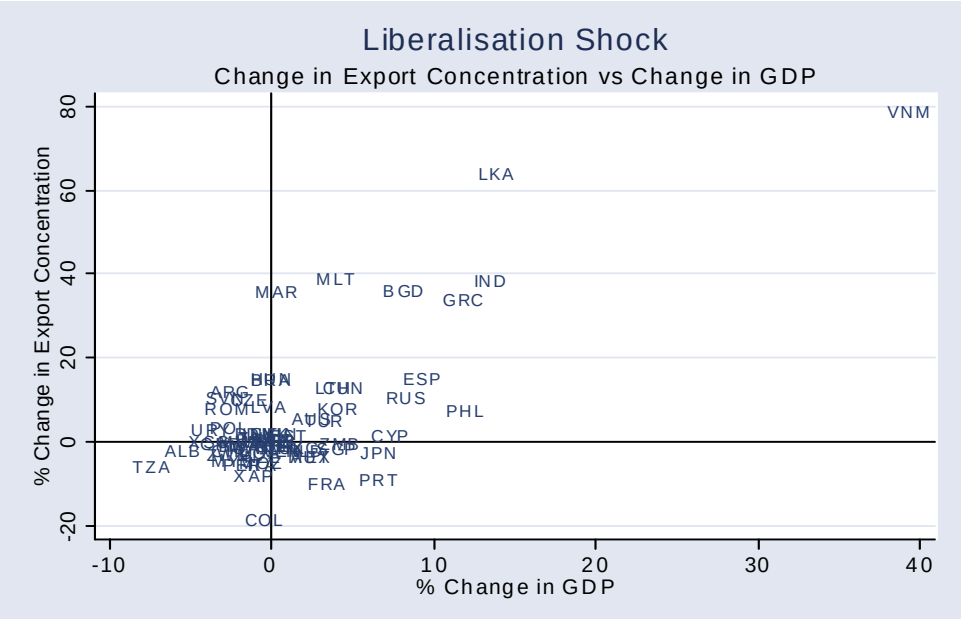
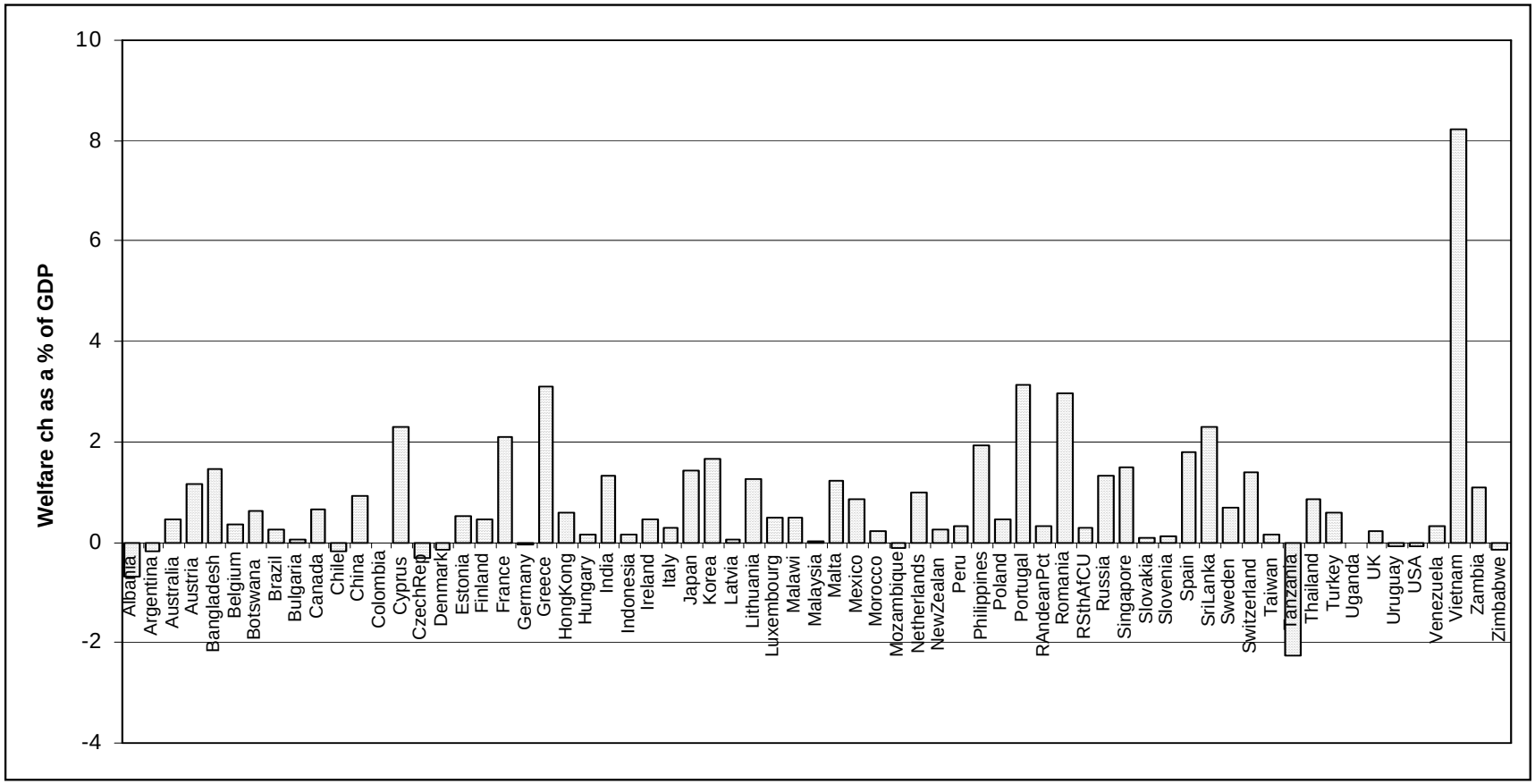


Figure 3: ***Change in welfare as a percentage of original GDP following liberalisation***



While figures such as 1-3 are useful to gain an overall picture of the results, ordinary least squares (OLS) regressions were also conducted for a more rigorous assessment, with the results given in Table 2. The regressions use robust standard errors following White (1980), as well as clustering, since the observations for each country are not independent of each other. Population data for 1997 for GDP per capita are from the World Bank (2004). The results show that while there is no evidence of a relationship between the percentage change in GDP and the initial export or output concentration, there is a positive relationship between the percentage change in GDP and the percentage change in export and output concentrations. So GDP gains from liberalisation do indeed tend to be associated with increases in export and output concentration. A one percentage point increase in output or export concentration, is associated with an average increase in GDP of around 0.3 percentage points for export concentration and 0.7 percentage points for output concentration.

There also appears to be negative relationships between the percentage change in GDP and the fractions of main export costs due to unskilled labour and, to a lesser extent, capital – though the coefficients on capital are no longer statistically significant with when export concentration is replaced by output concentration, so this result is not robust. The results for the fraction of main export costs due to unskilled labour however, are significant in all four models. The coefficients of around -16 to -19 imply that an increase of 0.1 in the fraction of unskilled labour in total costs employed by the main export sector is associated with a reduction in GDP of 1.6-1.9 percentage points, other things being equal. Land and natural resources are only significant in the second regression, once export concentration is accounted for, and both are used more intensively with increasing GDP.

The regression results imply that on average, increases in GDP following liberalisation are associated with increases in concentration in both the export sector and in overall industrial output and also reductions in the fraction of unskilled labour employed by the main export sector. Initial GDP per capita has no significant effect in any of the regressions, implying that once concentration measures and the fraction of costs in the main export are accounted for, the per capita income levels of a country show no systematic effects on the percentage change in GDP induced by the liberalisation.

For developing countries undergoing unilateral liberalisation though, the results imply that they are likely to experience an increase in GDP, but an increase accompanied by more highly concentrated industrial output and exports, and also a lower fraction of main export costs due to unskilled labour. Such a reduction in the fraction of unskilled labour costs could imply an absolute reduction in wages or employment of unskilled labourers (or both), or

instead simply an absolute increase in the costs of other inputs. Any combination of these would reduce the fraction of unskilled labour costs, and that combination is a country-specific empirical question, which must be investigated with a detailed analysis of the country simulation results.

Table 2: ***Ordinary least squares regression results for percentage change in GDP following the initial liberalisation***

Dependent variable: **% change in GDP post-liberalisation**	**OLS 1**	**OLS 2**	**OLS 3**	**OLS 4**
Constant	4.434	0.957	2.962	1.963
	(1.65)	(0.42)	(0.99)	(0.83)
GDP per capita pre-shock	-0.000	0.000	-0.000	0.000
	(1.13)	(0.72)	(1.20)	(0.64)
Export concentration pre-shock	3.430			
	(0.57)			
% change in export concentration		0.317***		
		(3.91)		
Output concentration pre-shock			24.133	
			(1.46)	
% change in output concentration				0.703***
				(4.05)
Fr of main export exported pre-shock	3.142	1.285	3.269	-0.891
	(0.57)	(0.61)	(0.71)	(0.41)
Fr of costs due to land pre-shock	-7.502	54.530***	-5.446	25.199
	(0.28)	(3.00)	(0.21)	(1.46)
Fr of costs due to unskilled labour pre-shock	-17.520*	-18.549**	-19.617**	-16.110*
	(1.90)	(2.08)	(2.31)	(1.70)
Fr of costs due to skilled labour pre-shock	28.968	12.738	31.573	5.831
	(0.98)	(0.56)	(0.96)	(0.25)
Fr of costs due to capital pre-shock	-12.480*	-9.872*	-14.321	-10.107
	(1.68)	(1.97)	(1.57)	(1.49)
Fr of costs due to natural resources pre-shock	-2.032	17.217*	-0.036	2.070
	(0.15)	(1.71)	(0.00)	(0.19)
Fr of costs due to own industry inputs pre-shock	-2.779	1.364	-2.444	-0.372
	(0.58)	(0.34)	(0.55)	(0.08)
Observations	67	67	67	67
R-squared	0.12	0.61	0.14	0.61

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

4. SIMULATION 2: TECHNOLOGICAL SHOCKS

It might be expected that undergoing complete unilateral liberalisation would increase a country's vulnerability, since it would be likely to be even more specialised and therefore more vulnerable to an external shock to that sector. The liberalisation simulations have already shown that liberalisation itself did not necessarily increase a country's export

concentration. But as the regression results show, increases in GDP are associated with increases in concentration in both exports and output. So overall, would liberalisation make countries more or less vulnerable to an external shock? Naturally it depends on the shock, but an obvious one to test is the effects of a substantial increase in the rest of the world's productivity in each country's main export. This type of shock can occur for a number of reasons, such as the widespread adoption of new technologies in the rest of the world, improvements in labour productivity, particularly favourable weather conditions for agricultural products, the opening of a major new mine for mineral products and so on. An increase in the rest of the world's productivity also helps to illustrate the importance of the fraction of the industries' own-commodity inputs in their total costs.

A new 'liberalised' version of each of the 67 regions was therefore created, based on the liberalisation undertaken in the first simulation. So there were now 67 'Liberalised' versions in addition to the original 67 'Non-Liberalised' versions. Each of these 134 versions was shocked with a 10% improvement in the rest of the world's output augmenting technological change (***aoall***) for the commodity making up the highest proportion of total exports in the original non-liberalised economy. Note that the shock does not imply any direct deterioration in the productivity of the domestic industry, simply and improvement in the productivity of the rest of the world.

In ten out of 67 cases, cases the leading export commodity in the pre-liberalisation version was no longer the lead commodity post-liberalisation. In this case the new lead export was shocked. The main point was to be able to compare the situation of the economy suffering a substantial shock to its most important export sector under two scenarios: Non-liberalisation, and Liberalisation, and to see which path left the country in better shape.

Tables 3 to 7 show that there is once again a significant variation in results. The results for tables 4 and 5 are summarized below in table 3. The liberalised economies fared marginally worse on average in welfare and terms of trade effects, but slightly better on GDP effects in the face of the technology shock. The two sets of results are nevertheless remarkably close.

Table 3: Summary statistics for technology shock results in Tables 4 and 5

	Table 3: Non-Liberalised				Table 4: Liberalised			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Ch GDP (%)	-3.575	2.625	-12.033	-0.423	-3.550	2.613	-11.277	0.229
Ch Welf (% GDP)	-0.764	1.123	-6.225	0.713	-0.772	1.141	-6.052	0.700
Ch TOT (%)	-1.943	2.695	-11.821	1.148	-1.993	2.624	-11.401	1.0988

Table 4: ***Results of the 10% shock to output augmenting technical change (aoall) in the rest of the world's production of countries' lead export – for Non-Liberalised versions.***

Country	*Lead Export Sector Shocked*	*Sector shocked fr of total exports to ROW*	*Fraction of main export output exported pre-shock*	*Fraction of costs due to own-commod inputs pre-shock*	*Change in GDP (%)*	*Change in welfare (% GDP)*	*Change in TOT (%)*
Albania	oil Oil	0.300	0.773	0.000	-3.041	0.406	-2.737
Argentina	vol Veg. oils & fats	0.143	0.391	0.079	-1.264	-0.147	-1.215
Australia	nfm Metals nec	0.117	0.625	0.180	-2.322	-0.378	-1.447
Austria	ome Machinery & equip.	0.176	0.722	0.148	-2.172	0.010	0.202
Bangladesh	wap Wearing apparel	0.466	0.870	0.007	-6.951	-1.334	-5.067
Belgium	crp Chem, rub & plast	0.184	0.868	0.370	-1.671	0.111	0.353
Botswana	omn Minerals nec	0.728	0.995	0.000	-11.341	-6.225	-10.208
Brazil	ome Machinery & equip.	0.094	0.088	0.169	-2.812	-0.067	-0.182
Bulgaria	crp Chem, rub & plast	0.138	0.083	0.230	-1.682	0.279	0.450
Canada	mvh Motor veh & parts	0.176	0.701	0.523	-1.826	-0.010	0.043
Chile	nfm Metals nec	0.271	0.730	0.079	-4.873	-1.192	-3.460
China	ele Electronic equip.	0.131	0.448	0.459	-1.347	-0.011	0.144
Colombia	ocr Crops nec	0.179	0.806	0.002	-1.616	-0.329	-1.754
Cyprus	oil Oil	0.353	0.979	0.000	-5.911	-2.397	-5.432
CzechRep	ome Machinery & equip.	0.172	0.537	0.408	-0.493	0.619	1.021
Denmark	ome Machinery & equip.	0.171	0.682	0.171	-2.195	0.115	0.195
Estonia	lum Wood prods	0.094	0.765	0.277	-1.192	-0.640	-0.556
Finland	ppp Paper & publishing	0.217	0.501	0.221	-3.711	-0.950	-2.093
France	ome Machinery & equip.	0.146	0.540	0.118	-1.803	0.150	0.233
Germany	ome Machinery & equip.	0.250	0.619	0.168	-2.676	-0.266	-0.819
Greece	obs Business serv nec	0.234	0.265	0.013	-4.338	-0.846	-2.191
HongKong	trd Trade	0.391	0.226	0.065	-5.090	-1.758	-2.901
Hungary	ome Machinery & equip.	0.145	0.860	0.150	-0.423	0.713	1.148
India	tex Textiles	0.140	0.171	0.238	-2.604	-0.322	-1.923
Indonesia	lum Wood prods	0.107	0.569	0.098	-1.700	-0.333	-1.232
Ireland	crp Chem, rub & plast	0.252	0.905	0.283	-4.149	-1.231	-1.385
Italy	ome Machinery & equip.	0.234	0.637	0.159	-3.045	-0.292	-1.024
Japan	ome Machinery & equip.	0.259	0.386	0.206	-3.802	-0.326	-2.618
Korea	ele Electronic equip.	0.257	0.702	0.258	-3.236	-0.509	-0.985
Latvia	lum Wood prods	0.164	0.864	0.109	-4.843	-2.568	-2.437
Lithuania	ely Electricity	0.124	0.524	0.223	-2.279	-0.430	-0.941
Luxembourg	crp Chem, rub & plast	0.187	0.875	0.403	-1.637	0.204	0.200
Malawi	ocr Crops nec	0.680	0.634	0.124	-8.797	-2.132	-7.620
Malaysia	ele Electronic equip.	0.453	0.920	0.255	-5.513	-0.943	-1.148
Malta	ele Electronic equip.	0.307	0.999	0.279	-4.043	-2.116	-0.450
Mexico	ome Machinery & equip.	0.220	0.763	0.106	-2.523	0.154	0.260
Morocco	wap Wearing apparel	0.229	0.647	0.067	-3.263	-0.903	-2.067
Mozambique	ofd Food prods nec	0.225	0.196	0.042	-12.033	-2.649	-8.762
Netherlands	crp Chem, rub & plast	0.154	0.687	0.363	-2.081	-0.298	0.056
NewZealand	mil Dairy prods	0.150	0.813	0.020	-1.606	-0.423	-1.458
Peru	nfm Metals nec	0.211	0.794	0.055	-3.312	-0.517	-2.563

Table 4 (cont): ***Results of the 10% shock to output augmenting technical change (aoall) in the rest of the world's production of countries' lead export – for <u>Non-Liberalised</u> versions.***

Country	*Lead Export Sector Shocked*	*Sector shocked fr of total exports to ROW*	*Fraction of main export output exported pre-shock*	*Fraction of costs due to own-commod inputs pre-shock*	*Change in GDP (%)*	*Change in welfare (% GDP)*	*Change in TOT (%)*
Philippines	ele Electronic equip.	0.377	0.947	0.624	-2.149	-0.775	-0.718
Poland	ome Machinery & equip.	0.107	0.306	0.229	-0.933	0.301	1.097
Portugal	mvh Motor veh & parts	0.103	0.488	0.322	-1.462	0.117	0.023
RAndeanPct	oil Oil	0.228	0.536	0.000	-4.180	-1.318	-4.168
Romania	wap Wearing apparel	0.162	0.868	0.030	-5.226	-1.543	-3.111
RSthAfCU	nfm Metals nec	0.247	0.770	0.213	-4.220	-1.022	-2.971
Russia	gas Gas	0.181	0.425	0.004	-1.483	-0.520	-2.480
Singapore	ele Electronic equip.	0.470	0.878	0.588	-4.530	-1.189	-0.806
Slovakia	ome Machinery & equip.	0.132	0.504	0.327	-0.599	0.617	1.131
Slovenia	ome Machinery & equip.	0.192	0.856	0.501	-1.072	0.061	0.315
Spain	mvh Motor veh & parts	0.163	0.686	0.219	-2.838	-0.358	-0.653
SriLanka	wap Wearing apparel	0.360	0.945	0.035	-7.708	-2.562	-4.496
Sweden	ome Machinery & equip.	0.197	0.788	0.219	-1.942	0.195	0.315
Switzerland	ome Machinery & equip.	0.302	0.763	0.159	-3.937	-0.563	-1.314
Taiwan	ele Electronic equip.	0.329	0.742	0.440	-3.127	-0.485	-0.953
Tanzania	ocr Crops nec	0.207	0.254	0.060	-3.078	-0.669	-2.581
Thailand	ele Electronic equip.	0.255	0.704	0.448	-2.709	-0.428	-0.630
Turkey	tex Textiles	0.123	0.544	0.297	-1.965	-0.365	-1.280
Uganda	ocr Crops nec	0.614	0.940	0.002	-9.022	-1.305	-7.948
UK	ome Machinery & equip.	0.157	0.452	0.164	-2.098	-0.013	-0.033
Uruguay	cmt Meat	0.107	0.328	0.049	-1.553	-0.427	-1.207
USA	ome Machinery & equip.	0.188	0.253	0.110	-2.312	-0.105	-0.722
Venezuela	oil Oil	0.481	0.648	0.000	-10.725	-3.322	-11.821
Vietnam	lea Leather prods	0.178	0.956	0.161	-6.532	-2.095	-2.376
Zambia	nfm Metals nec	0.571	0.997	0.010	-9.228	-2.453	-7.492
Zimbabwe	ocr Crops nec	0.288	0.717	0.000	-3.668	-1.212	-2.923

Table 5: ***Results of the 10% shock to output augmenting technical change (aoall) in the rest of the world's production of countries' lead export – for Liberalised versions.***

Country	*Lead Export Sector Shocked*		*Sector shocked fr of total exports to ROW*	*Fraction of main export output exported pre-shock*	*Fraction of costs due to own-commod inputs pre-shock*	*Change in GDP (%)*	*Change in welfare (% of original non-lib GDP)*	*Change in TOT (%)*
Albania	oil	Oil	0.281	0.782	0.000	-3.164	0.266	-2.852
Argentina	mvh	Motor veh & parts	0.144	0.183	0.364	-2.321	-0.028	-0.013
Australia	nfm	Metals nec	0.131	0.646	0.170	-2.480	-0.396	-1.656
Austria	ome	Machinery & equip.	0.169	0.707	0.144	-2.040	0.043	0.366
Bangladesh	wap	Wearing apparel	0.636	0.934	0.007	-5.164	-0.956	-3.701
Belgium	crp	Chem, rub & plast	0.182	0.869	0.366	-1.627	0.129	0.364
Botswana	omn	Minerals nec	0.721	0.996	0.000	-11.277	-6.052	-10.065
Brazil	mvh	Motor veh & parts	0.124	0.243	0.341	-2.342	-0.105	-0.367
Bulgaria	crp	Chem, rub & plast	0.138	0.083	0.230	-1.679	0.281	0.451
Canada	mvh	Motor veh & parts	0.174	0.702	0.516	-1.786	-0.007	-0.013
Chile	nfm	Metals nec	0.268	0.739	0.078	-4.735	-1.143	-3.363
China	wap	Wearing apparel	0.174	0.663	0.013	-2.258	-0.494	-1.477
Colombia	ocr	Crops nec	0.157	0.805	0.002	-1.384	-0.307	-1.479
Cyprus	oil	Oil	0.386	0.978	0.000	-6.329	-2.508	-5.809
CzechRep	ome	Machinery & equip.	0.185	0.569	0.404	-0.369	0.700	0.938
Denmark	ome	Machinery & equip.	0.167	0.684	0.171	-2.154	0.108	0.193
Estonia	lum	Wood prods	0.094	0.763	0.276	-1.174	-0.634	-0.562
Finland	ppp	Paper &, publishing	0.218	0.502	0.220	-3.693	-0.928	-2.102
France	crp	Chem, rub & plast	0.145	0.391	0.277	-1.945	-0.063	0.233
Germany	ome	Machinery & equip.	0.249	0.623	0.168	-2.654	-0.257	-0.816
Greece	obs	Business serv	0.294	0.247	0.011	-4.920	-1.024	-2.912
HongKong	trd	Trade	0.367	0.216	0.065	-4.850	-1.720	-2.647
Hungary	ele	Electricity	0.157	0.854	0.162	-0.359	0.293	0.433
India	wap	Wearing apparel	0.216	0.617	0.091	-2.909	-0.440	-2.456
Indonesia	lum	Wood prods	0.093	0.537	0.095	-1.488	-0.319	-1.024
Ireland	crp	Chem, rub & plast	0.245	0.906	0.276	-4.081	-1.240	-1.356
Italy	ome	Machinery & equip.	0.223	0.638	0.158	-2.918	-0.280	-0.930
Japan	ome	Machinery & equip.	0.261	0.285	0.194	-4.097	-0.389	-2.977
Korea	ele	Electronic equip.	0.274	0.717	0.237	-3.091	-0.410	-0.944
Latvia	lum	Wood prods	0.192	0.884	0.101	-5.277	-2.699	-2.773
Lithuania	p_c	Petroleum & coal	0.173	0.623	0.079	0.229	0.598	0.173
Luxembourg	crp	Chem, rub & plast	0.185	0.876	0.397	-1.579	0.227	0.222
Malawi	ocr	Crops nec	0.679	0.648	0.122	-8.099	-1.840	-7.203
Malaysia	ele	Electronic equip.	0.438	0.920	0.253	-5.388	-0.860	-1.066
Malta	ele	Electronic equip.	0.418	0.999	0.231	-5.284	-2.597	-1.642
Mexico	ome	Machinery & equip.	0.195	0.725	0.097	-2.287	0.136	0.493
Morocco	wap	Wearing apparel	0.330	0.819	0.056	-4.165	-1.082	-2.772
Mozambique	ofd	Food prods nec	0.209	0.191	0.041	-10.835	-2.285	-7.634
Netherlands	crp	Chem, rub & plast	0.152	0.686	0.356	-1.989	-0.267	0.069
NewZealand	mil	Dairy prods	0.145	0.806	0.020	-1.566	-0.416	-1.397
Peru	nfm	Metals nec	0.202	0.809	0.053	-3.070	-0.487	-2.346

Table 5 (cont): ***Results of the 10% shock to output augmenting technical change (aoall) in the rest of the world's production of countries' lead export – for <u>Liberalised</u> versions.***

Country	*Lead Export Sector Shocked*	*Sector shocked fr of total exports to ROW*	*Fraction of main export output exported pre-shock*	*Fraction of costs due to own-commod inputs pre-shock*	*Change in GDP (%)*	*Change in welfare (% of original non-lib GDP)*	*Change in TOT (%)*
Philippines	ele Electronic equip.	0.464	0.946	0.591	-2.106	-0.422	-1.104
Poland	ome Machinery & equip.	0.101	0.335	0.217	-0.919	0.284	1.099
Portugal	tex Motor veh & parts	0.106	0.495	0.179	-1.702	-0.276	-0.690
RAndeanPct	oil Oil	0.205	0.480	0.000	-3.749	-1.250	-4.080
Romania	wap Wearing apparel	0.177	0.945	0.025	-3.986	-1.211	-2.398
RSthAfCU	nfm Metals nec	0.249	0.776	0.213	-3.996	-0.932	-2.887
Russia	oil Oil	0.194	0.437	0.000	-2.536	-0.900	-4.155
Singapore	ele Electronic equip.	0.461	0.876	0.574	-4.566	-1.266	-0.821
Slovakia	ome Machinery & equip.	0.134	0.505	0.326	-0.632	0.617	1.070
Slovenia	ome Machinery & equip.	0.195	0.881	0.472	-1.129	0.096	0.125
Spain	mvh Motor veh & parts	0.194	0.677	0.206	-3.078	-0.352	-0.975
SriLanka	wap Wearing apparel	0.554	0.967	0.026	-10.880	-3.278	-6.746
Sweden	ome Machinery & equip.	0.204	0.786	0.217	-1.954	0.210	0.348
Switzerland	ome Machinery & equip.	0.298	0.763	0.158	-3.931	-0.546	-1.366
Taiwan	ele Electronic equip.	0.327	0.749	0.431	-3.054	-0.452	-0.969
Tanzania	ocr Crops nec	0.196	0.284	0.059	-2.864	-0.588	-2.340
Thailand	ele Electronic equip.	0.258	0.723	0.417	-2.556	-0.335	-0.649
Turkey	tex Textiles	0.127	0.570	0.283	-1.912	-0.349	-1.265
Uganda	ocr Crops nec	0.600	0.939	0.002	-8.683	-1.256	-7.641
UK	ome Machinery & equip.	0.153	0.440	0.161	-2.082	-0.019	0.002
Uruguay	cmt Meat	0.111	0.346	0.048	-1.570	-0.390	-1.269
USA	ome Machinery & equip.	0.188	0.263	0.109	-2.284	-0.098	-0.714
Venezuela	oil Oil	0.473	0.653	0.000	-9.981	-3.295	-11.401
Vietnam	wap Wearing apparel	0.331	0.991	0.037	-6.878	-2.956	-2.363
Zambia	nfm Metals nec	0.573	0.998	0.009	-8.908	-2.188	-7.315
Zimbabwe	ocr Crops nec	0.274	0.758	0.000	-3.324	-1.097	-2.596

Tables 6 and 7 below show the effects of liberalisation prior to the shocks. The final column of Table 6 shows that in 39 out of 67 cases, liberalisation prior to the shock left the country with worse welfare losses from terms of trade effects than it would otherwise have had. The final column of Table 7 shows however, that liberalisation left 55 out of the 67 countries better off in welfare terms than they would have been without it. This result is significant for two reasons: First, it shows that, given the assumptions of the GTAP model, liberalisation can be of significant benefit to developing countries. Second, and just as importantly however, it shows that this will by no means necessarily be the case. It depends on the country's economic structure. For 12 out of the 67 countries (17.9% of the sample) liberalisation left them worse off overall.

Table 6: ***Comparison of post-shock welfare effects due to terms of trade (TOT) changes for Liberalised and Non-Liberalised versions, sorted by difference.***

(Units: % of GDP in the original non-liberalised economy)

A positive value for the TOT Difference in the final column means the terms of trade would have been improved by liberalising before the shock hit.

Country	*Non-Liberalised Versions*			*Liberalised Versions*						*TOT Diff: Lib. minus Non-Lib.*
	Sector Shocked		*TOT change from shock*	*Sector Shocked*		*Diff sector from Non-Lib?*	*TOT change from initial lib.*	*TOT change from shock*	*Net TOT change from initial lib & shock*	
Singapore	ele	Manf	-1.197	ele	Manf	No	1.060	-1.077	-0.017	1.180
Cyprus	oil	Fuel	-2.195	oil	Fuel	No	0.876	-2.174	-1.297	0.898
Spain	mvh	Manf	-0.169	mvh	Manf	No	0.883	-0.190	0.693	0.862
Japan	ome	Manf	-0.306	ome	Manf	No	0.719	-0.285	0.434	0.740
Greece	obs	Serv	-0.376	obs	Serv	No	0.699	-0.434	0.265	0.641
Portugal	mvh	Manf	0.061	tex	Manf	Yes	0.681	-0.122	0.559	0.498
Austria	ome	Manf	0.081	ome	Manf	No	0.431	0.146	0.576	0.496
Korea	ele	Manf	-0.360	ele	Manf	No	0.382	-0.341	0.041	0.400
Netherlands	crp	Manf	0.024	crp	Manf	No	0.372	0.037	0.408	0.384
Mexico	ome	Manf	0.048	ome	Manf	No	0.278	0.150	0.428	0.380
Estonia	lum	Manf	-0.567	lum	Manf	No	0.351	-0.572	-0.222	0.345
Sweden	ome	Manf	0.116	ome	Manf	No	0.301	0.127	0.429	0.313
HongKong	trd	Serv	-1.167	trd	Serv	No	0.169	-1.085	-0.916	0.251
India	tex	Manf	-0.232	wap	Manf	Yes	0.245	-0.306	-0.062	0.170
Canada	mvh	Manf	-0.017	mvh	Manf	No	0.163	-0.011	0.152	0.168
Luxembourg	crp	Manf	0.176	crp	Manf	No	0.126	0.197	0.323	0.147
NewZealand	mil	Food	-0.393	mil	Food	No	0.084	-0.375	-0.291	0.103
Belgium	crp	Manf	0.264	crp	Manf	No	0.076	0.277	0.353	0.089
Finland	ppp	Manf	-0.835	ppp	Manf	No	0.085	-0.834	-0.749	0.086
Mozambique	ofd	Food	-1.273	ofd	Food	No	-0.082	-1.108	-1.190	0.083
Australia	nfm	Metal	-0.268	nfm	Metal	No	0.118	-0.304	-0.186	0.082
Turkey	tex	Manf	-0.288	tex	Manf	No	0.065	-0.285	-0.220	0.067
UK	ome	Manf	-0.008	ome	Manf	No	0.050	0.002	0.052	0.060
Botswana	omn	Metal	-6.750	omn	Metal	No	-0.024	-6.687	-6.711	0.039
Venezuela	oil	Fuel	-3.572	oil	Fuel	No	-0.040	-3.493	-3.533	0.038
Bulgaria	crp	Manf	0.279	crp	Manf	No	0.036	0.280	0.316	0.037
Uganda	ocr	Food	-0.930	ocr	Food	No	-0.008	-0.893	-0.901	0.029
Italy	ome	Manf	-0.253	ome	Manf	No	0.002	-0.232	-0.229	0.024
Ireland	crp	Manf	-1.096	crp	Manf	No	-0.039	-1.081	-1.121	-0.024
Germany	ome	Manf	-0.221	ome	Manf	No	-0.088	-0.224	-0.312	-0.091
Argentina	vol	Food	-0.109	mvh	Manf	Yes	-0.234	0.016	-0.218	-0.109
USA	ome	Manf	-0.080	ome	Manf	No	-0.109	-0.083	-0.192	-0.112
Vietnam	lea	Manf	-1.030	wap	Manf	Yes	0.060	-1.205	-1.145	-0.114

Table 6 (cont): ***Comparison of post-shock welfare effects due to terms of trade (TOT) changes for Liberalised and Non-Liberalised versions, sorted by difference.***

(Units: % of GDP in the original non-liberalised economy)

A positive value for the TOT Difference in the final column means the terms of trade would have been improved by liberalising before the shock hit.

Country	*Non-Liberalised Versions*			*Liberalised Versions*						*TOT Diff: Lib. minus Non-Lib.*
	Sector Shocked		*TOT change from shock*	*Sector Shocked*		*Diff sector from Non-Lib?*	*TOT change from initial lib.*	*TOT change from shock*	*Net TOT change from initial lib & shock*	
France	ome	Manf	0.058	crp	Manf	Yes	-0.137	0.058	-0.079	-0.138
Malawi	ocr	Food	-1.828	ocr	Food	No	-0.230	-1.770	-2.000	-0.172
Indonesia	lum	Manf	-0.340	lum	Manf	No	-0.220	-0.300	-0.520	-0.180
Lithuania	ely	Fuel	-0.533	p_c	Fuel	Yes	-1.093	0.335	-0.757	-0.224
Zambia	nfm	Metal	-2.069	nfm	Metal	No	-0.209	-2.108	-2.317	-0.247
Chile	nfm	Metal	-0.924	nfm	Metal	No	-0.281	-0.927	-1.207	-0.284
Uruguay	cmt	Food	-0.270	cmt	Food	No	-0.279	-0.293	-0.572	-0.302
Albania	oil	Fuel	-0.127	oil	Fuel	No	-0.270	-0.161	-0.431	-0.304
Denmark	ome	Manf	0.073	ome	Manf	No	-0.312	0.075	-0.237	-0.310
Taiwan	ele	Manf	-0.527	ele	Manf	No	-0.320	-0.528	-0.848	-0.321
Brazil	ome	Manf	-0.005	mvh	Manf	Yes	-0.336	-0.004	-0.339	-0.335
Bangladesh	wap	Manf	-0.642	wap	Manf	No	-0.394	-0.607	-1.000	-0.358
Russia	gas	Fuel	-0.534	oil	Fuel	Yes	-0.010	-0.898	-0.908	-0.374
Peru	nfm	Metal	-0.321	nfm	Metal	No	-0.373	-0.326	-0.699	-0.378
Slovakia	ome	Manf	0.749	ome	Manf	No	-0.361	0.724	0.362	-0.387
Switzerland	ome	Manf	-0.542	ome	Manf	No	-0.357	-0.574	-0.931	-0.389
RAndeanPct	oil	Fuel	-1.158	oil	Fuel	No	-0.384	-1.196	-1.581	-0.422
Thailand	ele	Manf	-0.297	ele	Manf	No	-0.443	-0.285	-0.728	-0.431
Zimbabwe	ocr	Food	-0.943	ocr	Food	No	-0.528	-0.872	-1.400	-0.457
Colombia	ocr	Food	-0.295	ocr	Food	No	-0.487	-0.281	-0.768	-0.472
Malaysia	ele	Manf	-1.244	ele	Manf	No	-0.617	-1.150	-1.768	-0.523
RSthAfCU	nfm	Metal	-0.761	nfm	Metal	No	-0.539	-0.805	-1.345	-0.583
CzechRep	ome	Manf	0.597	ome	Manf	No	-0.593	0.603	0.010	-0.587
China	ele	Manf	0.035	wap	Manf	Yes	-0.132	-0.431	-0.563	-0.598
Latvia	lum	Manf	-1.976	lum	Manf	No	-0.295	-2.314	-2.609	-0.633
Poland	ome	Manf	0.334	ome	Manf	No	-0.696	0.387	-0.309	-0.643
Romania	wap	Manf	-0.923	wap	Manf	No	-0.828	-0.793	-1.620	-0.698
SriLanka	wap	Manf	-1.454	wap	Manf	No	0.247	-2.455	-2.207	-0.753
Tanzania	ocr	Food	-0.442	ocr	Food	No	-0.780	-0.461	-1.241	-0.799
Hungary	ome	Manf	0.649	ele	Fuel	Yes	-0.534	0.255	-0.279	-0.927
Slovenia	ome	Manf	0.187	ome	Manf	No	-1.154	0.083	-1.071	-1.258
Malta	ele	Manf	-0.121	ele	Manf	No	-0.808	-0.941	-1.749	-1.628
Morocco	wap	Manf	-0.541	wap	Manf	No	-1.414	-0.924	-2.338	-1.797
Philippines	ele	Manf	-0.154	ele	Manf	No	-1.706	-0.252	-1.957	-1.803

Table 7: ***Comparison of post-shock total welfare changes for Liberalised and Non-Liberalised versions, sorted by difference. (Units: % of original GDP)***

A positive value for the welfare difference means that welfare would have been improved by liberalising before the shock hit.

Country	*Non-Liberalised Versions*			*Liberalised Versions*						*Welfare Diff: Lib. minus Non-Lib.*
	Sector Shocked		*Welfare change from shock*	*Sector Shocked*		*Diff sector from Non-Lib?*	*Welfare change from initial lib.*	*Welfare change from shock*	*Net Welfare change from initial lib & shock*	
Vietnam	lea	Manf	-2.095	wap	Manf	Yes	8.210	-2.956	5.255	7.349
Romania	wap	Manf	-1.543	wap	Manf	No	2.978	-1.211	1.767	3.309
Greece	obs	Serv	-0.846	obs	Serv	No	3.085	-1.024	2.061	2.907
Portugal	mvh	Manf	0.117	tex	Manf	Yes	3.140	-0.276	2.864	2.746
Philippines	ele	Manf	-0.775	ele	Manf	No	1.927	-0.422	1.505	2.280
Lithuania	ely	Fuel	-0.430	p_c	Fuel	Yes	1.251	0.598	1.848	2.278
Cyprus	oil	Fuel	-2.397	oil	Fuel	No	2.293	-2.508	-0.215	2.182
France	ome	Manf	0.150	crp	Manf	Yes	2.079	-0.063	2.016	1.866
Bangladesh	wap	Manf	-1.334	wap	Manf	No	1.444	-0.956	0.487	1.821
Spain	mvh	Manf	-0.358	mvh	Manf	No	1.802	-0.352	1.450	1.807
Korea	ele	Manf	-0.509	ele	Manf	No	1.647	-0.410	1.238	1.747
SriLanka	wap	Manf	-2.562	wap	Manf	No	2.303	-3.278	-0.975	1.587
Switzerland	ome	Manf	-0.563	ome	Manf	No	1.408	-0.546	0.862	1.426
Singapore	ele	Manf	-1.189	ele	Manf	No	1.478	-1.266	0.212	1.401
Japan	ome	Manf	-0.326	ome	Manf	No	1.433	-0.389	1.044	1.369
Zambia	nfm	Metal	-2.453	nfm	Metal	No	1.094	-2.188	-1.094	1.359
India	tex	Manf	-0.322	wap	Manf	Yes	1.318	-0.440	0.878	1.199
Austria	ome	Manf	0.010	ome	Manf	No	1.144	0.043	1.187	1.177
Netherlands	crp	Manf	-0.298	crp	Manf	No	1.004	-0.267	0.738	1.035
Russia	gas	Fuel	-0.520	oil	Fuel	Yes	1.341	-0.900	0.441	0.961
Thailand	ele	Manf	-0.428	ele	Manf	No	0.845	-0.335	0.510	0.939
Mexico	ome	Manf	0.154	ome	Manf	No	0.863	0.136	0.999	0.845
Botswana	omn	Metal	-6.225	omn	Metal	No	0.610	-6.052	-5.443	0.782
Malawi	ocr	Food	-2.132	ocr	Food	No	0.474	-1.840	-1.367	0.766
Malta	ele	Manf	-2.116	ele	Manf	No	1.233	-2.597	-1.364	0.751
Sweden	ome	Manf	0.195	ome	Manf	No	0.696	0.210	0.906	0.711
Canada	mvh	Manf	-0.010	mvh	Manf	No	0.666	-0.007	0.658	0.668
HongKong	trd	Serv	-1.758	trd	Serv	No	0.576	-1.720	-1.145	0.614
Turkey	tex	Manf	-0.365	tex	Manf	No	0.578	-0.349	0.230	0.595
Estonia	lum	Manf	-0.640	lum	Manf	No	0.518	-0.634	-0.116	0.524
Luxembourg	crp	Manf	0.204	crp	Manf	No	0.483	0.227	0.710	0.506
Finland	ppp	Manf	-0.950	ppp	Manf	No	0.452	-0.928	-0.477	0.473
Ireland	crp	Manf	-1.231	crp	Manf	No	0.471	-1.240	-0.768	0.463
Poland	ome	Manf	0.301	ome	Manf	No	0.467	0.284	0.751	0.449

Table 7 (cont): ***Comparison of post-shock total welfare changes for Liberalised and Non-Liberalised versions, sorted by difference. (Units: % of original GDP)***

A positive value for the welfare difference means that welfare would have been improved by liberalising before the shock hit.

Country	*Non-Liberalised Versions*		*Liberalised Versions*					*Welfare Diff: Lib. minus Non-Lib.*
	Sector Shocked	*Welfare change from shock*	*Sector Shocked*	*Diff sector from Non-Lib?*	*Welfare change from initial lib.*	*Welfare change from shock*	*Net Welfare change from initial lib & shock*	
Australia	nfm Metal	-0.378	nfm Metal	No	0.450	-0.396	0.054	0.432
China	ele Manf	-0.011	wap Manf	Yes	0.910	-0.494	0.416	0.426
RAndeanPct	oil Fuel	-1.318	oil Fuel	No	0.321	-1.250	-0.929	0.389
Belgium	crp Manf	0.111	crp Manf	No	0.368	0.129	0.497	0.386
RSthAfCU	nfm Metal	-1.022	nfm Metal	No	0.270	-0.932	-0.662	0.360
Peru	nfm Metal	-0.517	nfm Metal	No	0.310	-0.487	-0.177	0.340
Venezuela	oil Fuel	-3.322	oil Fuel	No	0.304	-3.295	-2.991	0.331
Italy	ome Manf	-0.292	ome Manf	No	0.275	-0.280	-0.006	0.286
NewZealand	mil Food	-0.423	mil Food	No	0.259	-0.416	-0.157	0.266
Mozambique	ofd Food	-2.649	ofd Food	No	-0.105	-2.285	-2.390	0.259
UK	ome Manf	-0.013	ome Manf	No	0.236	-0.019	0.217	0.230
Brazil	ome Manf	-0.067	mvh Manf	Yes	0.242	-0.105	0.137	0.204
Taiwan	ele Manf	-0.485	ele Manf	No	0.157	-0.452	-0.295	0.190
Indonesia	lum Manf	-0.333	lum Manf	No	0.164	-0.319	-0.155	0.178
Slovenia	ome Manf	0.061	ome Manf	No	0.106	0.096	0.201	0.140
Malaysia	ele Manf	-0.943	ele Manf	No	0.016	-0.860	-0.844	0.099
Slovakia	ome Manf	0.617	ome Manf	No	0.085	0.617	0.702	0.085
Morocco	wap Manf	-0.903	wap Manf	No	0.222	-1.082	-0.861	0.042
Bulgaria	crp Manf	0.279	crp Manf	No	0.037	0.281	0.318	0.039
Uganda	ocr Food	-1.305	ocr Food	No	-0.013	-1.256	-1.269	0.036
Colombia	ocr Food	-0.329	ocr Food	No	-0.008	-0.307	-0.316	0.013
Uruguay	cmt Food	-0.427	cmt Food	No	-0.067	-0.390	-0.457	-0.030
Zimbabwe	ocr Food	-1.212	ocr Food	No	-0.152	-1.097	-1.248	-0.036
Germany	ome Manf	-0.266	ome Manf	No	-0.053	-0.257	-0.310	-0.044
Argentina	vol Food	-0.147	mvh Manf	Yes	-0.182	-0.028	-0.210	-0.063
Latvia	lum Manf	-2.568	lum Manf	No	0.055	-2.699	-2.644	-0.076
USA	ome Manf	-0.105	ome Manf	No	-0.097	-0.098	-0.195	-0.090
Denmark	ome Manf	0.115	ome Manf	No	-0.135	0.108	-0.027	-0.142
Chile	nfm Metal	-1.192	nfm Metal	No	-0.193	-1.143	-1.336	-0.144
CzechRep	ome Manf	0.619	ome Manf	No	-0.317	0.700	0.383	-0.236
Hungary	ome Manf	0.713	ele Fuel	Yes	0.150	0.293	0.443	-0.270
Albania	oil Fuel	0.406	oil Fuel	No	-0.695	0.266	-0.429	-0.835
Tanzania	ocr Food	-0.669	ocr Food	No	-2.265	-0.588	-2.853	-2.184

Lowess plots, or locally weighted scatter plots, such as those in figures 4 and 5 below, may be used to gain an impression of the relationships between welfare changes and other influences (see for example Imbs & Wacziarg, 2003). Lowess plots are constructed by calculating a separate weighted regression for each data point so that points closest to it get the greatest weighting in the calculation of the smoothed line (Cleveland, 1979; Goodall 1990; Royston, 1992).

Figure 4: ***Lowess Plot for Non-Liberalised economies of the change in welfare as a percentage of GDP following the 10% technical change shock against the degree of export concentration existing prior to the shock.***

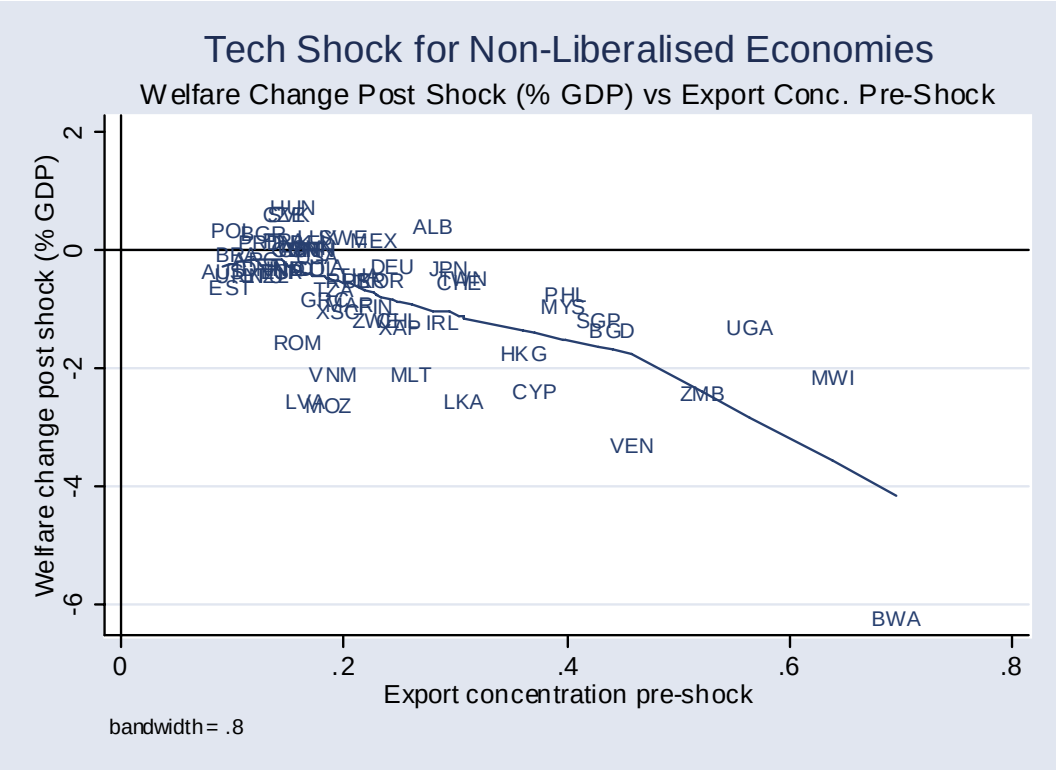
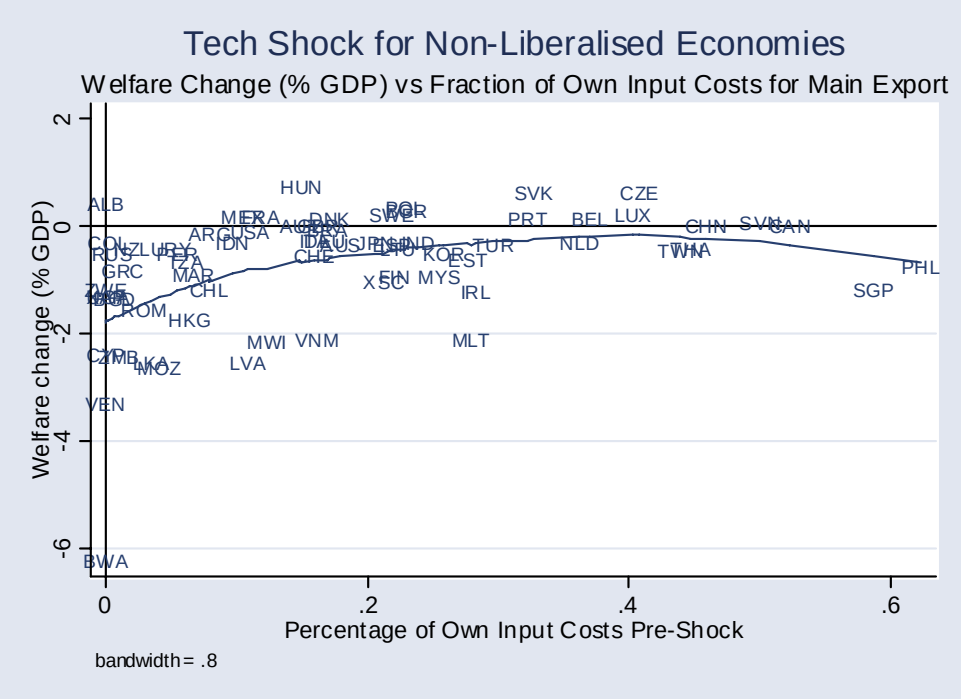


Figure 4 shows a clear negative relationship between post-shock welfare changes and pre-shock export concentration for the non-liberalised economies. The picture for liberalised economies looks very similar. In both cases, countries with higher export concentration tended to fare worse. Figure 5 shows a more complex picture of the relationship between welfare changes and the fraction of own-commodity inputs, but on the whole, welfare improved the most for cases with high fractions of own-commodity inputs. For a more rigorous assessment of these relationships, multivariate regression analysis is needed again. Ordinary Least Squares (OLS) regressions were therefore undertaken for the Non-Liberalised and Liberalised versions, with the results reported in Table 8 below.

Figure 5: ***Lowess plot for Non-Liberalised economies of the change in welfare as a percentage of GDP after the 10% technical change shock against the fraction of total costs of the main export industry accounted for by own-commodity inputs prior to the shock.***



A number of results are apparent from the regressions in Table 8. The strongly significant negative coefficients on initial export concentration and (perhaps more surprisingly) initial output concentration, the positive coefficients on the fraction of the main export industry's total costs due to skilled labour and to its own-commodity inputs prior to shock, and also once again, the lack of any significance for GDP per capita. Naturally a productivity shock to a nation's lead export sector is likely to have a greater impact if its export sector is highly concentrated, but the fact that the coefficient for output concentration is just as strongly statistically significant and more than two and a half times as large as that for export concentration was unexpected since the shock targeted only one industry. The size of the coefficients imply that initial export or output concentration levels higher by 0.1, are associated with welfare changes around 0.47 percentage points lower for export concentration and 1.33 percentage points lower for output concentration.

The coefficients of around 1.9 for the fraction of own-commodity inputs imply that a fraction 0.1 higher is associated with an improvement in welfare of around 0.19 percentage points of original GDP. The positive relationship between welfare change and the fraction of own-commodity inputs was expected since a sector with a high proportion of its own-commodity inputs used for production, will benefit more from an improvement in the rest of the world's

productivity in producing those inputs – especially if it has already undertaken liberalisation to reduce the costs of imported inputs.

Table 8: ***Regression results for welfare changes following the 10% output augmenting technical change shock for both Non-Liberalised and Liberalised versions***

Dependent variable: **welfare change (% GDP)**	OLS Non-Liberalised		OLS Liberalised	
Constant	0.115	0.808*	0.266	1.184**
	(0.25)	(1.95)	(0.57)	(2.55)
GDP per capita pre-shock	0.000	0.000	-0.000	0.000
	(0.23)	(1.47)	(1.12)	(1.19)
Export concentration pre-shock	-4.767***		-4.359***	
	(5.15)		(4.27)	
Output concentration pre-shock		-13.193***		-13.524***
		(4.49)		(5.26)
Fr of main export exported pre-shock	-0.313	-0.987***	-0.110	-0.781**
	(0.67)	(2.81)	(0.24)	(2.27)
Fr of costs due to land pre-shock	5.208	4.600	5.986	6.136*
	(1.53)	(1.51)	(1.51)	(1.90)
Fr of costs due to unskilled labour pre-shock	0.521	0.878	-0.531	-0.262
	(0.32)	(0.55)	(0.31)	(0.14)
Fr of costs due to skilled labour pre-shock	4.806	5.950	7.333**	5.835*
	(1.54)	(1.56)	(2.26)	(1.70)
Fr of costs due to capital pre-shock	-1.966	-1.728	-2.237*	-2.140*
	(1.48)	(1.47)	(1.67)	(1.96)
Fr of costs due to natural resources pre-shock	2.998	1.449	1.014	0.018
	(1.13)	(0.41)	(0.61)	(0.01)
Fr of costs due to own industry inputs pre-shock	2.056***	1.997***	1.927***	1.594***
	(4.11)	(4.04)	(3.19)	(2.90)
Observations	67	67	67	67
R-squared	0.64	0.61	0.63	0.63

Robust t statistics in parentheses 'Fr of costs' refers to fraction of costs in the main export
* significant at 10%; ** significant at 5%; *** significant at 1%

It is important then to ask which sectors have high levels of own-commodity input costs. The answer can be seen in Table 9 below. Overwhelmingly it is manufactured goods – such as electronic goods, motor vehicles, chemicals rubber and plastics, machinery and equipment and textiles. While this result is inevitably influenced by the level of aggregation in the data, it also makes perfect sense. Electrical goods and machinery require electrical components and other machines to build them, whereas the coffee and tobacco industries require comparatively little coffee and tobacco as direct inputs (except perhaps as required by the workers to keep them going). A boost in the rest of the world's productivity therefore will hurt manufacturing industries to the extent that they lose competitiveness technologically, but help them to the extent they gain due to cheaper inputs.

Table 9: ***Fraction of economies' lead export industries' total costs due to own-industry inputs prior to the rest of the world's technological improvement shock (sorted from highest fraction to lowest).*** See Appendix 1 for sector classifications.

Non-Liberalised Economies				***Liberalised Economies***			
Country	***Lead export sector shocked & classification***		***Fraction of costs due to own-commodity inputs pre-shock***	***Country***	***Lead export sector shocked & classification***		***Fraction of costs due to own-commodity inputs pre-shock***
Philippines	ele	Manf	0.624	Philippines	ele	Manf	0.591
Singapore	ele	Manf	0.588	Singapore	ele	Manf	0.574
Canada	mvh	Manf	0.523	Canada	mvh	Manf	0.516
Slovenia	ome	Manf	0.501	Slovenia	ome	Manf	0.472
China	ele	Manf	0.459	Taiwan	ele	Manf	0.431
Thailand	ele	Manf	0.448	Thailand	ele	Manf	0.417
Taiwan	ele	Manf	0.44	CzechRep	ome	Manf	0.404
CzechRep	ome	Manf	0.408	Luxembourg	crp	Manf	0.397
Luxembourg	crp	Manf	0.403	Belgium	crp	Manf	0.366
Belgium	crp	Manf	0.37	Argentina	mvh	Manf	0.364
Netherlands	crp	Manf	0.363	Netherlands	crp	Manf	0.356
Slovakia	ome	Manf	0.327	Brazil	mvh	Manf	0.341
Portugal	mvh	Manf	0.322	Slovakia	ome	Manf	0.326
Turkey	tex	Manf	0.297	Turkey	tex	Manf	0.283
Ireland	crp	Manf	0.283	France	crp	Manf	0.277
Malta	ele	Manf	0.279	Estonia	lum	Manf	0.276
Estonia	lum	Manf	0.277	Ireland	crp	Manf	0.276
Korea	ele	Manf	0.258	Malaysia	ele	Manf	0.253
Malaysia	ele	Manf	0.255	Korea	ele	Manf	0.237
India	tex	Manf	0.238	Malta	ele	Manf	0.231
Bulgaria	crp	Manf	0.23	Bulgaria	crp	Manf	0.23
Poland	ome	Manf	0.229	Finland	ppp	Manf	0.22
Lithuania	ely	Fuel	0.223	Poland	ome	Manf	0.217
Finland	ppp	Manf	0.221	Sweden	ome	Manf	0.217
Spain	mvh	Manf	0.219	RSthAfCU	nfm	Metal	0.213
Sweden	ome	Manf	0.219	Spain	mvh	Manf	0.206
RSthAfCU	nfm	Metal	0.213	Japan	ome	Manf	0.194
Japan	ome	Manf	0.206	Portugal	tex	Manf	0.179
Australia	nfm	Metal	0.18	Denmark	ome	Manf	0.171
Denmark	ome	Manf	0.171	Australia	nfm	Metal	0.17
Brazil	ome	Manf	0.169	Germany	ome	Manf	0.168
Germany	ome	Manf	0.168	Hungary	ele	Fuel	0.162
UK	ome	Manf	0.164	UK	ome	Manf	0.161
Vietnam	lea	Manf	0.161	Italy	ome	Manf	0.158
Italy	ome	Manf	0.159	Switzerland	ome	Manf	0.158
Switzerland	ome	Manf	0.159	Austria	ome	Manf	0.144
Hungary	ome	Manf	0.15	Malawi	ocr	Food	0.122

Table 9 (cont): ***Fraction of economies' lead export industries' total costs due to own-industry inputs prior to the rest of the world's technological improvement shock (sorted from highest fraction to lowest).*** See Appendix 1 for sector classifications.

Non-Liberalised Economies				***Liberalised Economies***			
Country	***Lead export sector shocked & classification***		***Fraction of costs due to own-commodity inputs pre-shock***	***Country***	***Lead export sector shocked & classification***		***Fraction of costs due to own-commodity inputs pre-shock***
Austria	ome	Manf	0.148	USA	ome	Manf	0.109
Malawi	ocr	Food	0.124	Latvia	lum	Manf	0.101
France	ome	Manf	0.118	Mexico	ome	Manf	0.097
USA	ome	Manf	0.11	Indonesia	lum	Manf	0.095
Latvia	lum	Manf	0.109	India	wap	Manf	0.091
Mexico	ome	Manf	0.106	Lithuania	p_c	Fuel	0.079
Indonesia	lum	Manf	0.098	Chile	nfm	Metal	0.078
Argentina	vol	Food	0.079	HongKong	trd	Serv	0.065
Chile	nfm	Metal	0.079	Tanzania	ocr	Food	0.059
Morocco	wap	Manf	0.067	Morocco	wap	Manf	0.056
HongKong	trd	Serv	0.065	Peru	nfm	Metal	0.053
Tanzania	ocr	Food	0.06	Uruguay	cmt	Food	0.048
Peru	nfm	Metal	0.055	Mozambique	ofd	Food	0.041
Uruguay	cmt	Food	0.049	Vietnam	wap	Manf	0.037
Mozambique	ofd	Food	0.042	SriLanka	wap	Manf	0.026
SriLanka	wap	Manf	0.035	Romania	wap	Manf	0.025
Romania	wap	Manf	0.03	NewZealand	mil	Food	0.02
NewZealand	mil	Food	0.02	China	wap	Manf	0.013
Greece	obs	Serv	0.013	Greece	obs	Serv	0.011
Zambia	nfm	Metal	0.01	Zambia	nfm	Metal	0.009
Bangladesh	wap	Manf	0.007	Bangladesh	wap	Manf	0.007
Russia	gas	Fuel	0.004	Colombia	ocr	Food	0.002
Colombia	ocr	Food	0.002	Uganda	ocr	Food	0.002
Uganda	ocr	Food	0.002	Albania	oil	Fuel	0
Albania	oil	Fuel	0	Botswana	omn	Metal	0
Botswana	omn	Metal	0	Cyprus	oil	Fuel	0
Cyprus	oil	Fuel	0	RAndeanPct	oil	Fuel	0
RAndeanPct	oil	Fuel	0	Russia	oil	Fuel	0
Venezuela	oil	Fuel	0	Venezuela	oil	Fuel	0
Zimbabwe	ocr	Food	0	Zimbabwe	ocr	Food	0

The differences between the sectors can also be seen in the summary statistics presented in Table 10 comparing the outcomes of the non-liberalised and liberalised economies following a shock to the original lead export sector. On average, countries were around 0.768% of their GDPs better off in total welfare terms if they had liberalised. However this result masks important sectoral differences. In economies where the lead export sectors were fuels (0.884%), manufacturing (0.948%) or metals (0.521%), they would have been even better off, but for economies with food as the leading export sector, they would have been worse off by liberalising – by about 0.114% of GDP. For the terms of trade component of welfare, overall countries were an average of around -0.172 % of their GDPs worse off due to terms of trade effects if they had liberalised prior to the shock. On average lead exports in the food, fuel, manufacturing and metals sectors all fared badly, but again the food sector fared the worst, with an average loss of 0.248% of GDP due to terms of trade effects. Given the importance of the fraction of own-commodity inputs to the results, the fact that countries specialising in fuels did so well is noteworthy, since fuels have the lowest fraction of own-commodity inputs of any sector. The reason is that the higher overseas productivity in fuel stimulated the domestic economies leading to strong welfare gains despite the relative loss of competitiveness of the domestic fuel sector.

Table 10: ***Summary statistics of the differences in outcomes for Non-Liberalised and Liberalised economies for welfare and terms of trade, for main export sectors.***

All numbers refer to the difference between Liberalised and Non-liberalised outcomes, measured in percentage of original GDP. A positive number for the mean indicates that liberalisation prior to the shock would have been beneficial. Argentina and Hungary were excluded from the sectoral summary statistics because they changed not only their lead export following liberalisation, but also the sector.

Terms of trade effects	*All*	*Food*	*Fuel*	*Manf*	*Metal*
Observations	67	8	6	43	6
Mean	-0.172	-0.248	-0.065	-0.178	-0.229
Standard Deviation	0.564	0.320	0.499	0.639	0.253
Low	-1.803	-0.799	-0.422	-1.803	-0.583
High	1.180	0.103	0.898	1.180	0.082
Total welfare	*All*	*Food*	*Fuel*	*Manf*	*Metal*
Observations	67	8	6	43	6
Mean	0.768	-0.114	0.884	0.948	0.521
Standard Deviation	1.219	0.878	1.195	1.289	0.506
Low	-2.184	-2.184	-0.835	-0.236	-0.144
High	7.349	0.766	2.278	7.349	1.359

Clearly these are not large results on average, though there are some quite large individual values at the extremes. The decline in Tanzania's welfare, equivalent to 2.184% of GDP for example, represents a loss of around US$142 million, an amount equal to around 47% of Tanzania's total expenditure on health in 1997 (World Bank, 2004). Moreover, the shock administered, a 10% relative decline in productivity in just one export sector (albeit the lead one), was not terribly large either, so the fact that there are some strong results is noteworthy. The results here concur with econometric results based on World Bank and UNCTAD data presented elsewhere (Parris, 2003). Lower export concentration is associated on average with better welfare measures for developing countries.

Before concluding this section, there is one other feature of the data that is worth mentioning. Figures 6 and 7 show lowess plots of export concentration and output concentration against GDP per capita for Non-Liberalised economies prior to the shock. Clearly there is no strong overall relationship between the degree of export concentration and GDP per capita, although only the poorer countries tend to have high levels of export concentration. The exceptions are Cyprus (oil), Singapore (electronic equipment) and Hong Kong (trade). Output concentration conversely, tends to increase somewhat with GDP per capita. This suggests that many poorer countries may be overly diversified in their overall output base, while at the same time being too reliant on a narrow range of exports.

Figure 6: ***Lowess plot for Non-Liberalised economies prior to the shock of export concentration against GDP per capita.***

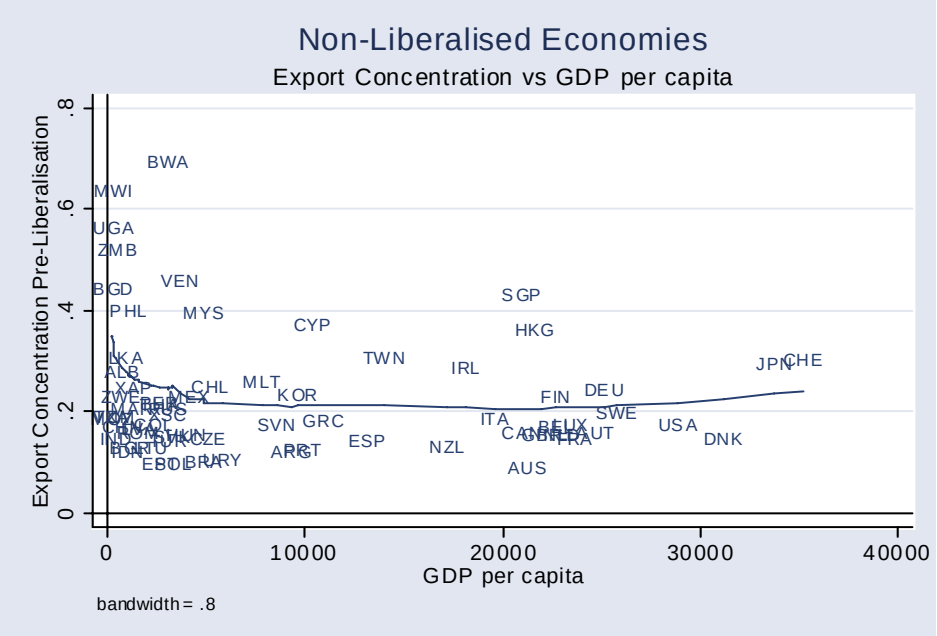
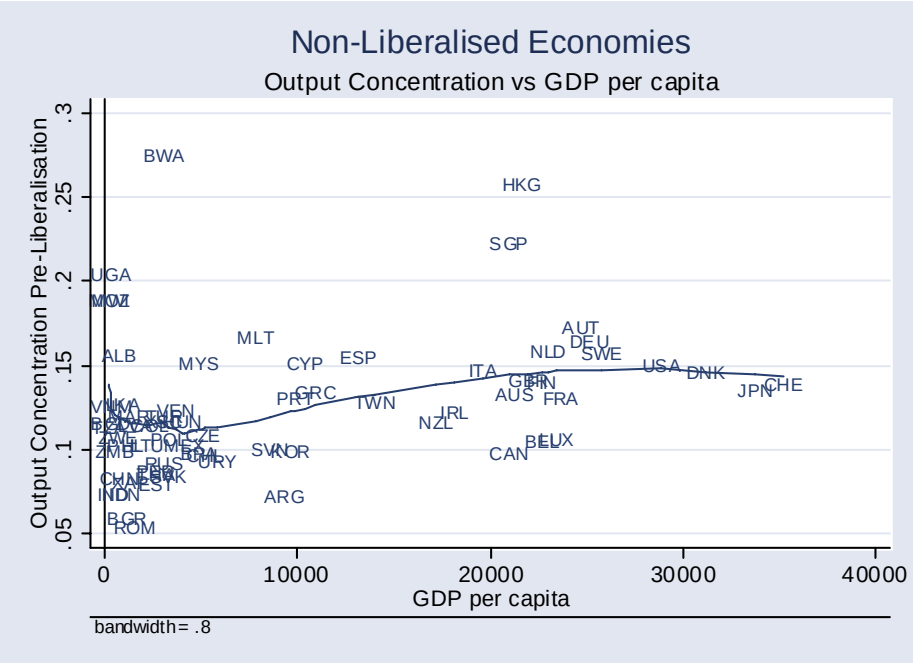


Figure 7: ***Lowess plot for Non-Liberalised economies prior to the shock of output concentration against GDP per capita.***



5. VISUALISING ECONOMIC NETWORK INDUSTRIAL STRUCTURES

Visualising the network structure of economies can be a useful means of getting a feel for the dominant sectors of an economy and the linkages between them. Aggregation of sectors according to the scheme in the Appendix was necessary to make the diagrams clearer. It is possible to design a square matrix showing all industry inputs and all output destinations, but the resulting diagram is still too complex. Instead the input and output networks are separated, with the matrices presented in figures 8 and 10 below, and network diagrams comparing the two extreme cases from the analysis, Tanzania and Vietnam, in figures 9 and 11. The diagrams are drawn using *Netdraw* (Borgatti, 2002) and show nodes and link sizes in approximate proportion to their sector size and value. The diagrams are somewhat simplified however, in that bidirectional flows between nodes with different values are presented as single lines with arrows at each end, rather than separate weighted unidirectional lines, and the diagrams also do not show own-commodity inputs as loops back to the originating node. These simplifications reflect the limitations of currently available software, but nevertheless the diagrams do give a good feel for the sizes of flows and the relative importance of various sectors.

Figure 8: ***Matrix structure of domestic industry inputs***

An x refers to an entry of data, with other cells filled with zeros.

VFM(i,j,r): Firm's expenditure on endowments i by j in r valued at market prices

VDFM(i,j,r): Firm's purchases of domestic good i for use by j in region r at market prices

VIFM(i,j,r): Firm's purchases of imported good i for use by j in region r at market prices

D_CGDS = Domestic capital goods industry

VOM(i,r) = Value of commodity i output in region r at market prices

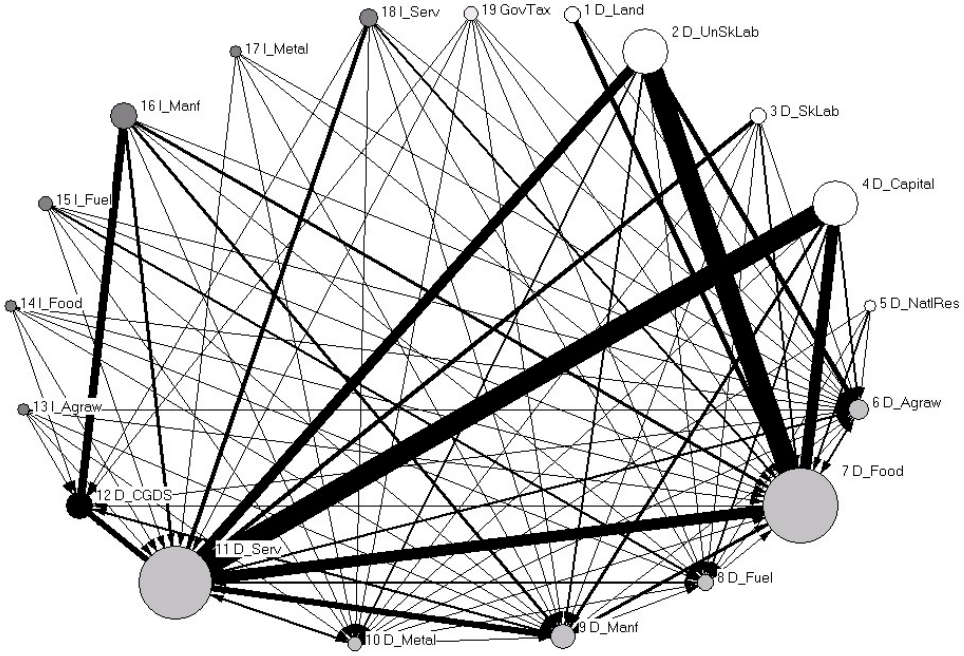
GovTax = ETAX + DFTAX + IFTAX + PTAX, where:

ETAX(i,j,r) = Tax on use of endowment good i by ind j in region r
DFTAX(i,j,r) = Tax on domestic intermediate input i for use by ind j in region r
IFTAX(i,j,r) = Tax on use of imported intermediate good i by ind j in r
PTAX(i,r) = Output tax on good i in region r

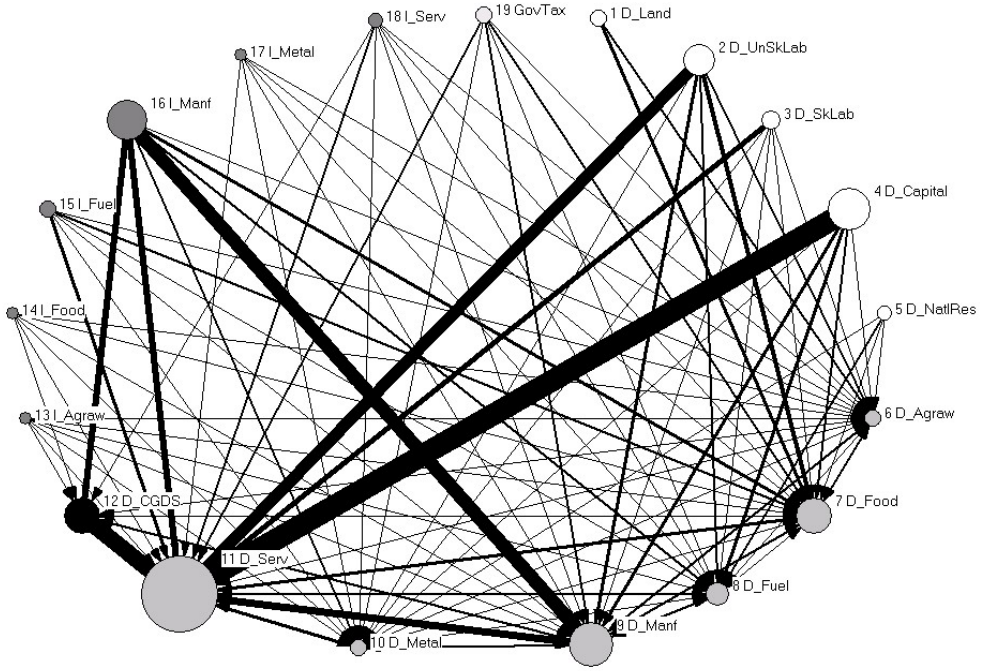
		DOMESTIC OUTPUT					
		Domestic factors of production 1 to 5: VFM	Domestic producer industries 6 to 11: VDFM	12 D_CGDS	Imported producer industries 13 to 18: VIFM	19 Gov Tax	
INPUTS (ALL SOURCES)	Domestic factors of production 1 to 5: VFM	0 0 0 0 0	x x x x x x	0	0 0 0 0 0 0	0	Row totals = total usage/ endowment of domestic factors
		0 0 0 0 0	x x x x x x	0	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	0	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	0	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	0	0 0 0 0 0 0	0	
	Domestic producer industries 6 to 11: VDFM	0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	Row totals = total inputs of domestic industries into domestic production
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
	12 D_CGDS	0 0 0 0 0	0 0 0 0 0 0	0	0 0 0 0 0 0	0	
	Imported producer industries 13 to 18: VIFM	0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	Row totals = Total value of imports for production
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
		0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	
	19 GovTax	0 0 0 0 0	x x x x x x	x	0 0 0 0 0 0	0	Row total = total government production taxes
			Column totals = Total inputs to domestic producer industries = Size of output, VOM	Column total = Regional gross investment			

Figure 9: ***Comparison of the input network structures of Tanzania and Vietnam (Non-liberalised versions)***

Tanzania



Vietnam



D_ = Domestic I_ = Imported

Figure 10: ***Matrix structure of domestic industry outputs***

An x refers to an entry of data, with other cells filled with zeros.

VDFM(i,j,r): Firm's purchases of domestic good i for use by j in region r at market prices

D_CGDS = Domestic capital goods industry

VDPM(i,r) = Private consumption expenditure on domestic i in r at market prices

VDGM(i,r) = Government consumption expenditure on domestic i in r at market prices

VST(m,r) = Exports of margin commodities from r for international transport valued at market prices

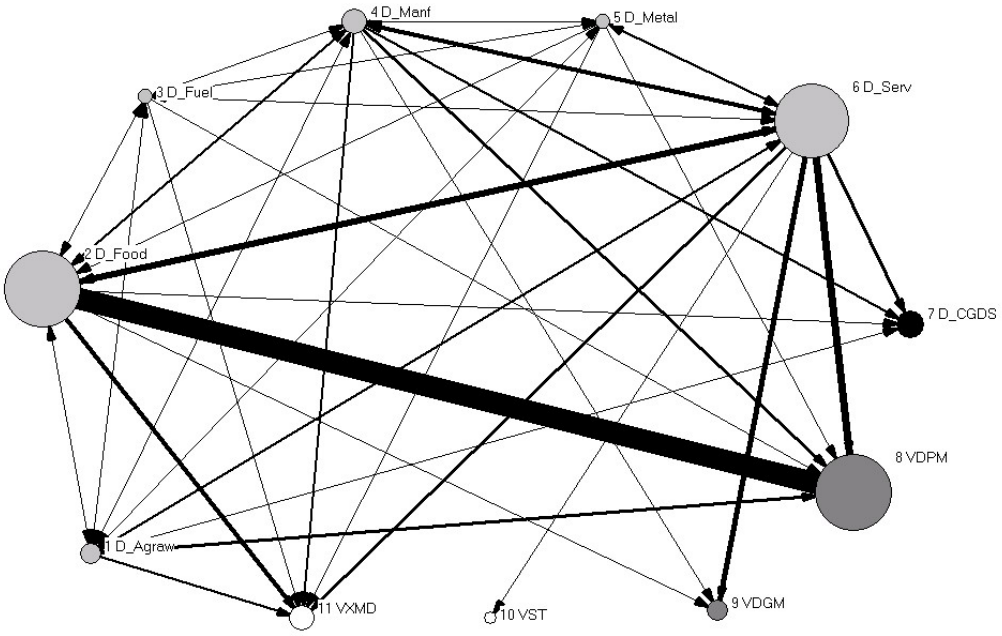
VXMD(i,r,s) = exports of i from r to s valued at mkt prices

VOM(i,r) = Value of commodity i output in region r at market prices

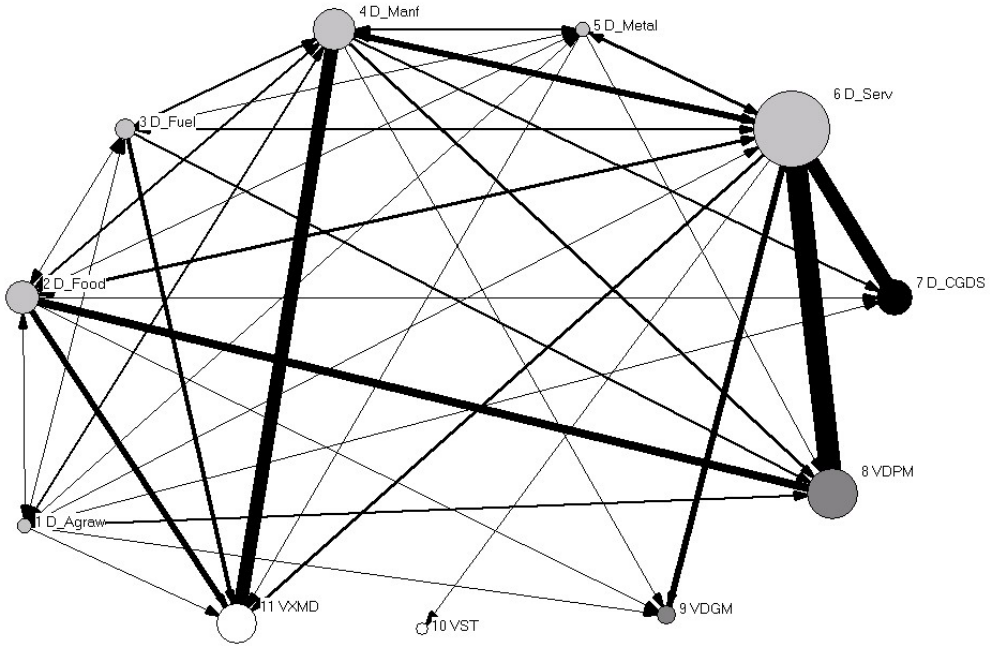
		DESTINATION						
		Domestic producer industries 1 to 6: VDFM	7 D_CGDS	8 VDPM	9 VDGM	10 VST	11 VXMD	
INPUTS	Domestic producer industries 1 to 6 inputs: VDFM	x x x x x x	x	x	x	0	x	Row totals = sales of domestic commodities in rows to destinations in columns = size of domestic industry, VOM
		x x x x x x	x	x	x	0	x	
		x x x x x x	x	x	x	0	x	
		x x x x x x	x	x	x	0	x	
		x x x x x x	x	x	x	0	x	
		x x x x x x	x	x	x	x	x	
	7 D_CGDS	0 0 0 0 0 0	0	0	0	0	0	
	8 VDPM	0 0 0 0 0 0	0	0	0	0	0	
	9 VDGM	0 0 0 0 0 0	0	0	0	0	0	
	10 VST	0 0 0 0 0 0	0	0	0	0	0	
	11 VXMD	0 0 0 0 0 0	0	0	0	0	0	
		Column totals = sales of all domestic industry inputs to industries in columns		Column totals = sales to destinations in columns				

Figure 11: ***Comparison of the output network structures of Tanzania and Vietnam (Non-liberalised versions)***

Tanzania



Vietnam



D_ = Domestic industries
D_CGDS = Domestic capital good sector
VDPM = Private consumption
VDGM = Government consumption
VXMD = Exports
VST = Sales to international transport sector

Figures 9 and 11 show some significant difference between the economic structures of Tanzania and Vietnam. On the input side in figure 9 it is immediately apparent that the domestic food and services sectors dominate the Tanzanian economy. Both absorb a large proportion of unskilled labour and capital. Unskilled labour inputs to all sectors also vastly outweigh inputs of skilled labour. Imports of manufactures tend to be absorbed most by domestic capital goods, and to a lesser extent by the services, manufacturing and food sectors. For Vietnam the pool of unskilled labour is still larger than skilled labour, but the ratio is not as large as in Tanzania. The food sector is now smaller than the manufacturing sector, which absorbs a large flow of imported manufactures for production.

On the output side, figure 11 shows that the output of the Tanzanian food sector, which absorbs such a great proportion of inputs, is almost entirely consumed by the domestic private sector. In other words, Tanzanian agriculture is geared overwhelmingly to satisfying domestic demand, with relatively little exported. Food is still the main export but not by much, with other sectors such as agricultural raw materials, manufacturing and services contributing to exports in roughly equal measure. Clearly the proportion of goods exported does not reflect the relative sizes of those sectors in the Tanzanian economy, suggesting an anti-export bias in the domestic food sector. For Vietnam, two features stand out: First, a far greater absorption of domestic services by the private sector than was the case in Tanzania. Since private consumption of food is roughly proportional to population size (adjusted for income), the increase in service absorption relative to food reflects a higher flow of services rather than a lower flow of food. Second, output for exports is dominated by manufacturing, which, as seen in figure 9, absorbed a very large proportion of imported manufactures as inputs. It makes sense then that Vietnam did so well from liberalising imports and from a technological shock that increased the rest of the world's productivity in manufactures. Tanzania conversely had little to gain for is main export sector from liberalisation or the technological shock, since its main inputs were all domestic: unskilled labour, services and capital.

This sort of visual assessment is no substitute for detailed analysis of model simulation results, but it is a useful aid to interpretation and certainly suggests possibilities that warrant more rigorous investigation.

6. CONCLUSIONS

The purpose of this paper was to analyse the effects, if any, of export and output concentration on countries' responses to economic shocks such as liberalisation and a deterioration in relative productivity in the lead export sector. Five main conclusions can be drawn:

- First, a general-equilibrium framework which accounts for cascading economic effects following a shock is essential, rather than a simple partial equilibrium analysis.
- Second, countries exhibited a wide variety of responses to the liberalisation and subsequent technology shock. In general increased GDP following liberalisation tended to be associated with an increased degree of export and output concentration, and a reduced fraction of unskilled labour costs in the country's main export. While liberalisation prior to the technology shock benefited the majority of the countries in welfare terms (if not in terms of trade terms) a significant minority (almost 18%) were made worse off. It should not be assumed that liberalisation will necessarily benefit a country – at least in the short run. Detailed, dynamic, country-specific simulations are needed.
- Third, whether a country benefits from liberalisation or an improvement in the rest of the world's productivity in its main export depends on the fraction of own-commodity inputs needed for production. Manufacturing industries such as electronic equipment and wearing apparel tend to have the highest levels of own-commodity input costs and so can benefit more strongly from liberalisation. Industries such as food crops in poor countries, which rely overwhelmingly on domestic inputs such as unskilled labour, may find themselves worse off.
- Fourth, higher initial levels of export and output concentration tended to reduce welfare following the technology shock. This suggests that increased concentration does indeed make countries more vulnerable to certain economic shocks than they would otherwise have been.
- Finally, network visualization of the input and output structures of an economy's industries can be a useful aid in suggesting important economic linkages and the possible effects of economic shocks.

Future work in this area will involve a similar analysis of the version 6 GTAP database and the analysis of a broader range of network statistics to assess economic structures.

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APPENDIX: GTAP COMMODITY CODE NAMES AND CLASSES

Code	Description	Class	Code	Description	Class
1 pdr	Paddy Rice	Food	30 lum	Wood products	Manf
2 wht	Wheat	Food	31 ppp	Paper products, publishing	Manf
3 gro	Cereal grains n.e.c.	Food	32 p_c	Petroleum, coal products	Fuel
4 v_f	Vegetables, fruits, nuts	Food	33 crp	Chemical, rubber, plastic products	Manf
5 osd	Oil seeds	Food	34 nmm	Mineral products n.e.c.	Manf
6 c_b	Sugar cane, sugar beet	Food	35 i_s	Ferrous metals	Manf
7 pfb	Plant-based fibres	Agraw	36 nfm	Metals n.e.c.	Metal
8 ocr	Crops n.e.c.	Food	37 fmp	Metal products	Manf
9 ctl	Bovine cattle, sheep and goats, horses	Food	38 mvh	Motor vehicles and parts	Manf
10 oap	Animal products n.e.c.	Agraw	39 otn	Transport equipment n.e.c.	Manf
11 rmk	Raw milk	Food	40 ele	Electronic equipment	Manf
12 wol	Wool, silk-worm cocoons	Agraw	41 ome	Machinery and equipment n.e.c.	Manf
13 for	Forestry	Agraw	42 omf	Manufactures n.e.c.	Manf
14 fsh	Fishing	Food	43 ely	Electricity	Fuel
15 col	Coal	Fuel	44 gdt	Gas manufacture, distribution	Fuel
16 oil	Oil	Fuel	45 wtr	Water	Serv
17 gas	Gas	Fuel	46 cns	Construction	Serv
18 omn	Minerals n.e.c.	Metal	47 trd	Trade	Serv
19 cmt	Bovine meat products	Food	48 otp	Transport n.e.c.	Serv
20 omt	Meat products n.e.c.	Food	49 wtp	Water transport	Serv
21 vol	Vegetable oils and fats	Food	50 atp	Air transport	Serv
22 mil	Dairy products	Food	51 cmn	Communication	Serv
23 pcr	Processed rice	Food	52 ofi	Financial services n.e.c.	Serv
24 sgr	Sugar	Food	53 isr	Insurance	Serv
25 ofd	Food products n.e.c.	Food	54 obs	Business services n.e.c.	Serv
26 b_t	Beverages and tobacco products	Food	55 ros	Recreational and other services	Serv
27 tex	Textiles	Manf	56 osg	Public Admin., Defense, Education, Health	Serv
28 wap	Wearing apparel	Manf	57 dwe	Dwellings	Serv
29 lea	Leather products	Manf			

This classification is based on the SITC classifications used by the World Bank and UNCTAD, using the GTAP concordance for merchandise trade compiled by Mark Gellhar (2000). Some GTAP sectors mix SITC categories. For example, while sector 30 has the abbreviation 'lum' for lumber, and it does contain raw logs, it also contains a large number of manufactured wood products (including aircraft seats) so it is classed as 'Manf' rather than 'Agraw'. Similarly, we might expect sectors 34 'mineral products' and 35 'ferrous metals' to come under metals, but in fact they are mainly manufactured goods. Category 10 'Animal products' mainly consists of hides, skins, ivory, fur etc and so is classed as 'Agraw'. Sectors 43 'electricity' and 44 'gas manufacture and distribution' may be thought of as services, but in fact have SITC 3 codes and so were classified as 'Fuel'.

Agraw = Agricultural raw materials (SITC 2 - except 22, 27 & 28)
Food = Food products (SITC 0, 1, 22 & 4)
Fuel = Fuels and oils (SITC 3)
Manf = Manufactured goods (SITC 5, 6, 7, 8 - except 68)
Metals = Metals and ores (SITC 27, 28, 68)
Serv = Services