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Economic Impact and Global Trade Implications of Phytosanitary Treatments for Wood Packaging Material

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Abstract

With increases in global trade, wood packaging material (WPM) has become an increasingly significant pathway by which bark- and wood-boring insects move between countries. Recognising this threat, an international standard for the treatment of WPM (ISPM 15) is being implemented by many countries. This standard requires that WPM associated with exports be heat treated or fumigated with methyl bromide. In addition, the United States is currently considering the application of this standard to WPM used in its domestic trade. Our study uses a domestic margin-inclusive version of the GTAP model, along with the version 7 GTAP database, to estimate the effects of ISPM 15. We model international implementation of ISPM 15 in varying levels of stringency, along with the impact of United States domestic implementation of this standard. Changes in transport margins due to ISPM 15 are based on empirical estimates of the share of WPM in sectoral transport costs. Preliminary results indicate that the implementation of ISPM 15 is likely to have a small but negative effect on exports and traditional measures of economic welfare for most countries. However, there is significant regional and sectoral variation, depending in part on the product mix traded, along with the relative size of the pallet margins in these sectors. Implementation of ISPM 15 that involves higher heat treatments leads to somewhat more adverse impacts, while the more extreme scenario of requiring plastic pallets leads to much more significant impacts. When ISPM 15 implementation includes United States domestic trade, the impacts on the United States are stronger, as expected. However, these results must to be tempered with the benefits of the regulation in terms of potential averted damages due to non-native bark- and wood-boring insects and reduced spread of already established insect pests. These averted damages are being estimated in a separate study.

Keywords: wood packaging material, Cerambycidae, Scolytidae, phytosanitary regulation, international trade, general equilibrium

1 Introduction

Wood packaging material (WPM; e.g. pallets, crating, dunnage) is recognized as an important pathway by which bark- and wood-boring insects move among countries (Haack 2001, 2006, Brockerhoff et al. 2006, McCullough et al. 2006, Zahid et al. 2008, Haack and Petrice 2009). This pathway has grown in importance due to increased United States imports from China, a large proportion of which are shipped on WPM (Jabara et al. 2008), and recent establishments in the United States and elsewhere of Asian wood-boring insects such as emerald ash borer (*Agrilus planipennis*) (Haack et al. 2002) and the Asian longhorned beetle (*Anoplophora glabripennis*) (Haack et al.2010).

Recognising this threat, an international standard for the treatment of WPM was adopted in 2002 designated as International Standards for Phytosanitary Measures No. 15 (ISPM 15; FAO 2002, Haack and Petrice 2009). In an attempt to facilitate trade of commodities associated with WPM, wood that has received the ISPM 15 treatment is stamped as such. The intention is that this will signify that the risk of infestation is negligible and thus quarantine inspection of such material is not required, therefore avoiding delays in shipping (FAO 2002). Since 2005 the now 173 signatory countries to the International Plant Protection Convention (IPPC) are over varying dates adopting the ISPM 15 standard, with over 50 countries now implementing the standard.

The purpose of this study was to estimate the effects of ISPM 15 phytosanitary requirements on bilateral commodity trade flows and country welfare, using a multi-commodity model of global and domestic trade; the Global Trade Analysis Project model with domestic margins (GTAP-M, Peterson 2006). The research presented here is part of a larger study to assess for the United States the costs, in terms of lost trade, and benefits, in terms of averted pest damage, of ISPM 15.

The remainder of this section includes a description of the phytosanitary regulation analysed and a review of economic methods for assessing the trade impacts of phytosanitary regulations. Next a description of study methods beginning with the data used to describe the different phytosanitary regulation scenarios and the implementation of these scenarios in the GTAP-M model are covered. This is followed by a presentation of the results in terms of the impact of the phytosanitary regulation scenarios on country trade flows and welfare. We then provide a discussion of the results and finish with some tentative conclusions.

1.1 ISPM 15 Phytosanitary Regulations

The International Plant Protection Convention (IPPC) ISPM 15 regulation applies to all export-associated WPM manufactured from raw wood traded among parties to the regulation. WPM must be heat treated or fumigated with methyl bromide and marked as being appropriately treated in order to kill pests in the wood at the time of treatment (FAO 2002, Haack and Petrice 2009). Based on efficacy studies (e.g. Mushrow et al. 2004, Uzunovic 2006) treatment involves heating the WPM to a core temperature of 56ºC for at least 30 min.

In September 2005 the United States, Mexico and Canada implemented the first of three phases of enforcement of the ISPM 15 standard, with full enforcement of the standard starting July 5, 2006. At that time (2006) a similar treatment requirement had already been in effect since 1999 for WPM from China to United States, given that various Asian wood borers had been found in WPM from China (Haack et al. 2010). The 2006 regulation did not apply to United States-Canada trade because these countries' share a long common border and have many common forest pests. In May 2009, ISPM 15 was extended to include the elimination of bark of at least credit card size (50 cm^2) when the board is more than 3 cm thick (FAO 2009). This is to reduce the likelihood of insect infestation after treatment as many borers require larger bark patches for successful oviposition and development (Evans 2007, Haack and Petrice 2009).

There are two possible future changes to ISPM 15. The first includes an increase in the stringency of heat treatment by either increasing the required core temperature, hold time, or a combination of both. The rationale for such changes is based in part on recent laboratory studies showing that some emerald ash borer larvae appear to be tolerant of the current ISPM 15 heat-treatment schedule (McCullough et al. 2007; Nzokou et al. 2008; Myers 2010). The second is that ISPM 15 will be required for WPM used in United States domestic and United States-Canada trade (Federal Register 2009). In the study presented here, we also explore the possibility, as an extreme scenario, of an outright ban on the use of wood packaging material, motivated by reported finds of exotic invasive pests on ISPM 15 stamped WPM (Zahid et al. 2008).

2 Estimating the Trade Impacts of Phytosanitary Regulations

Reviews of approaches to estimate trade impacts (or lost gains from trade) of phytosanitary regulations include Beghin and Bureau (2001) and Maskus et al. (2001). Approaches include partial equilibrium, gravity, and computable general equilibrium models.

Partial equilibrium models have been used to assess the trade implications of phytosanitary regulations for wood products by Prestemon et al. (2007) for the United States ban on log imports from Russia, and Turner et al. (2007) for a ban and debarking requirement on New Zealand log exports to China, Japan and Korea. Both of these studies used the Global Forest Products Model (Buongiorno et al. 2003). Partial equilibrium models have been a fruitful approach for predicting the effects of regulations to reduce the risk of importing exotic pests (Beghin and Bureau 2001).

Gravity models (Bergstrand 1985, 1989) are suited to *ex post* analysis of the trade impacts of phytosanitary regulations. Gravity models have previously been used to assess the trade implications of phytosanitary regulations and standards by Disdier et al. (2008) and Otsuki et al. (2001). These studies have included a measure of the phytosanitary regulation in the estimated gravity model, e.g., a dummy variable if a bilateral trade flow has a regulation in effect. Interestingly, a number of studies have found that standards have a trade facilitating effect, i.e., increasing trade among countries. Beghin and Bureau (2001) identified gravity models as a promising area of research, particularly for assessing the magnitude of barriers to trade.

Computable general equilibrium (CGE) models enable analysis of cross-sectoral impacts of phytosanitary regulations (Beghin and Bureau 2001); an obvious aspect of WPM, which is used among a wide range of commodities, and hence sectors. CGE models such as the Global Trade Analysis Project (GTAP) model, use a database of detailed bilateral trade, transport and tariff data that characterise regional linkages and input-output tables that describe inter-sector linkages within regions (Hertel 1999). An earlier study by Jabara et al. (2008) used the GTAP model to assess the trade implications of phytosanitary regulations by for ISPM 15.

2.1 Methods

In this study we used a domestic margin inclusive version of the GTAP database (GTAP-M), recently updated to the version 7 database (Peterson 2006, Peterson & Lee 2009).[1] This facilitates exploration of the requirement for ISPM 15 treated WPM for United States domestic and United-States-Canada trade, two of the largest global trade flows (U.S. DoC 2009). GTAP-M contains marketing (or distribution) activities such as transportation, wholesaling and retailing associated with all intermediate input purchases by firms, purchases by households, and purchases by governments of domestically produced and imported commodities. The model also includes all domestic trade and transport margins required to get exported goods to the "border" and imported goods from the "border" to domestic users. These marketing activities are carried out by the trade, water transport, air transport and other transport sectors in the GTAP Model.

The key contribution of GTAP-M is that the marketing margins associated with the purchase of specific commodities are allocated to the appropriate margin activity, rather than, as is done in most applied general equilibrium analysis, having marketing services only purchased separately from commodities. Inclusion of domestic marketing services in the standard GTAP Model has been shown to change the degree of price transmission from producers to users, which has significant implications for the estimated production and consumption impacts of policies modeled (Peterson 2006).

2.2 Scenarios Analysed

In this study we assess four scenarios. First we consider three alternative scenarios impacting on the cost of shipping goods internationally (Table 1).[2]

The first scenario is ISPM 15 as currently being implemented; methyl bromide or heat treatment to 56ºC to the core for 30 min and no restrictions on bark (FAO 2002). This is similar to the scenario assessed by Jabara et al. (2008), using a cost of US$2.00

[1] We are very grateful to Everett Peterson for generously making his model and domestic margins database available to us.
[2] Represented in the GTAP-M model by a decrease in the productivity of transport services used to ship goods internationally.

per pallet.[3] The recent maximum bark area requirement (FAO 2009) is expected to result in no significant increase on the marginal cost of ISPM 15.[4] This first scenario (FAO 2002) did not include United States-Canada and United States-China bilateral trade flows.

The second scenario is ISPM 15 with a higher heat treatment requirement. This is expected to add $0.50 above the current cost of implementing ISPM 15 on a per pallet basis.[4] For this scenario, the marginal change in transport service productivity was applied to United States-China bilateral trade, but was not applied to United States-Canada bilateral trade.

The third scenario is replacement of wood packaging material with plastic pallets, which range in cost from being similar to wood pallets to over three times the cost.[5] Plastic pallets of equivalent weight capacity and suitable for reuse in international shipping are approximately US$14.00 per pallet more than new wood pallets.[6] For this scenario, the marginal change in transport service productivity was applied to United States-China bilateral trade, but was not applied to United States-Canada bilateral trade.

The final scenario further assesses the first scenario for the impact it would have were it also applied to United States domestic and United States-Canada bilateral trade. These scenarios were represented in GTAP-M by applying a decrease in transport services productivity to these trade flows (see below for details).

2.3 Data

The shares of pallet value in international transport costs used in this study (Table 1) are from Jabara et al. (2008) calculated as the share of pallet value divided by the transport margin between cost, insurance and freight (c.i.f.) and customs import value (c.i.v.) of imports. These pallet margin shares represent the proportion of international shipping costs that are due to pallet costs. These are influenced by the pallet usage and value of trade within a sector.

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[3] http://www.uline.com/BL_8201/Wood-Pallets
[4] based on an email survey of various international wood packaging industry and association representatives
[5] http://www.uline.com/Grp_147/Pallets
[6] http://www.uline.com/BL_8206/Industrial-Plastic-Pallets

Here we assume that the share of pallet value in international transport costs calculated by Jabara et al. (2008), for United States imports, are the same for imports by all countries and for United States domestic trade. This is reasonable given the standardization of international shipping, particularly for products shipped in containers using pallets (Hummels 2007, Levinson 2008).

2.4 Model

We use a 24-region, 27-sector aggregation of the GTAP version 7 database, including margins (Narayanan & Walmsley 2008; Peterson & Lee 2009).[7] The 24-regions were identified based on major trade flows and bio-geographical regions. The 22 sectors follow those previously used by Jabara et al. (2008), which were defined by aggregating sectors with similar magnitudes of pallet use relative to the total cost of transporting goods. In addition the four marketing service sectors (trade, air, water and other transport) and an additional services sector were included. Full details of the aggregation are provided in Appendices 1 and 2.

The change in transport margins in international bilateral trade due to ISPM 15 (Table 1) was implemented as a reduction in the technical efficiency of transport margin services; atmfsd(m,i,r,s) for margin commodity *m*, used by good *i*, transported from region *r* to region *s*.[8] This technical change parameter, along with the change in the margin inclusive export sales (qxls) determines the percentage change in the quantity of bilateral international margin usage (qtmfsd):

$$\text{qtmfsd}(m,i,r,s) = \text{qxls}(i,r,s) - \text{atmfsd}(m,i,r,s); \qquad [1]$$

We assume that the percentage change in bilateral transport margin costs due to ISPM 15 is equivalent to a change in the quantity of margin services required for the bilateral trade (Table 1).

In GTAP-M, technical change in marketing services is modelled as a biased technical change, only affecting the quantity of the m^{th} marketing service associated with the marketing of a good (Peterson 2006). Using this representation of marketing service

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[7] With a base year of 2004.

[8] Except United States-China, China-United States, United States-Canada, and Canada-United States bilateral trade.

demand, the effects on commodity demand are indirect through lower margins and lower retail prices (Peterson 2006).

Changes in domestic margins due to an ISPM15 type policy implemented in the United States and for United States-Canada bilateral trade are represented as a decrease in the United States technical efficiency, *anfd(i,m,j,r)*, of transport margins, *m* (excluding the trade sector), used by firms producing intermediate goods, for all input goods *i* (Table 1) used to produce good *j*, *anpd(i,m,r)*, for delivering goods to private households and *angd(i,m,r)*, for delivering goods to the government. Each of these technical change variables influences the quantity of the m^{th} marketing service associated with the domestic movement of domestically produced goods in the same way.[9] For example, for the quantity of the m^{th} marketing service required for the i^{th} domestically produced good consumed by private households (Peterson 2006):

$$\begin{aligned} qnpd(i,m,r) &= qrpd(i,r) - anpd(i,m,r) + \\ &\quad \mathrm{ESUBPL}(i)*[prpd(i,r) + anpd(i,m,r) - pm(m,r)] \qquad [2] \end{aligned}$$

where *qrpd(i,r)* and *prpd(i,r)*[10] are the aggregate quantity and price of marketing services incorporated in domestically produced good *i*, ESUBPL(i) is the elasticity of substitution among marketing services,[11] and *pm(m,r)* is the domestic market price of the m^{th} marketing service in region *r*.

Due to a lack of data on differences in WPM use in air, water and land transport we assume here that the cost of ISPM 15 is the same for the same good shipped using different transport services. As such, the change in *anpd(i,m,r,)* was the same for all transport margins *m*, however margins for the trade sector were assumed unchanged.

[9] In GTAP-M, the same marketing services technical change parameter is applied to imported goods as domestically produced goods (Peterson 2006). However, we modified this in the current study to accommodate different technological change for domestic and imported products. Imported products have already had ISPM 15 implemented therefore no further impacts were imposed on these.
[10] The aggregate price of marketing services *prpd(i,r)* will also be impacted by the technical efficiency of domestic margins.
[11] The default value of ESUBPL is zero.

3 Results and Discussion

3.1 Welfare and real GDP impacts of each scenario

Most regions experience reductions in real output and welfare,[12] as shown in Table 2. The exception is Canada, which is not included in the ISPM 15 regulations in the first three scenarios. The reductions in welfare are generally small across all regions. Applying a more stringent ISPM 15 policy for heat treatment does lead to significantly larger welfare losses relative to the current stringency of ISPM 15; approximately 25% to 30% larger losses across all regions, though this remains a relatively small welfare impact. As expected, the welfare impact from the most extreme scenario of requiring plastic pallets for international transportation is significantly higher. Turning to changes in real GDP, we find that even in the most extreme scenario, these range from reductions of 0.26 to under 0.01 percent (Table 2).

The largest reductions in economic welfare are for East Asia, West Europe, the United States, China and South Europe. However, some of these impacts can be explained by the fact that these are relatively large economic regions; while the absolute magnitude of the loss is relatively large, it may not be significant relative to the size of these economies. Therefore, more useful insights may perhaps be gained by focusing on regions which experience relatively large reductions in real GDP. From Table 2, we find that the regions most affected in terms of real GDP reductions are Polynesia, the Rest of Europe and West Africa. On examining the base-data trade flows, we find that these composite regions tend to have relatively high proportions of trade in commodities with high pallet margins, and consequent costs of implementing ISPM 15. For Polynesia and the Rest of Europe, it is exports of processed food products that are relatively important, while for West Africa, the category of miscellaneous pallet-using agricultural product exports, which includes other plant and animal based products such as cut flowers and honey, are particularly important. Both of these product categories are expected to incur the highest costs if ISPM 15 implementation becomes more stringent (see Table 1). Turning to the imports of these regions that will be impacted by ISPM 15 costs, for each of the three regions, it is imports of other processed foods that are relatively important.

[12] As measured by an equivalent variation in income (Hertel, 1999).

Turning to results for the United States, we find that the welfare losses resulting from the three scenarios for ISPM 15 applied in international trade are relatively small, ranging from US$586 million for the current policy to approximately US$7 billion for a shift to plastic pallets. In the fourth scenario that applies the current stringency of ISPM 15 to domestic and US-Canada trade, the welfare losses of US$4.6 billion for the United States are less than the most stringent international policy. In terms of changes in real GDP, even in the most extreme simulation modelled, the associated percentage reduction in real GDP for the United States is less than 0.03 percent (Table 2).[13]

3.2 International trade impacts of each scenario

Overall real exports are reduced for most countries with the implementation of ISPM 15 policies of varying stringency, however, the impacts tend to be relatively small, as shown in Table 3. The pattern of reductions in exports is similar across all scenarios, though the more stringent scenarios naturally have greater impacts. For the first scenario, reductions in real exports are up to 0.08 percent. For the second scenario that requires a higher heat treatment, the reduction in exports is up to 0.1 percent of real exports. Impacts on exports are of course the greatest in the third and most stringent scenario that requires plastic pallets, with exports reduced by up to 0.63 percent. The countries or regions that tend to experience particularly strong declines in exports include South America, China and South Asia. Several countries and regions experience slight increases in exports under each scenario modelled. The Rest of Europe is particularly striking, with an increase in exports of 0.4 percent in the first simulation, 0.5 percent in the second and 3.2 percent in the third. This region experienced the largest reduction in real GDP because its exports have high pallet margins (Table 2). As a consequence, factor incomes declined particularly strongly in this region, driving an increase in relative export competitiveness that was more than sufficient to offset the reduction in exports caused by higher transportation costs.

Under each scenario, real imports decline for most countries (Table 4) as international transport costs rise. Particularly strongly impacted are Central and South America, the Caribbean, the Rest of Europe and Africa. There appears to be a

[13] Changes in welfare include impacts due to changes in allocative efficiency, changes in terms of trade and changes in productivity of margins (Huff and Hertel, 2001) and are sometimes rather different to changes in real GDP.

positive correlation between reductions in real imports and real GDP, with the above-mentioned regions experiencing particularly significant reductions in both real GDP and real imports (Table 2 and Table 4).. In particular, the Rest of Europe was expected to have the most substantial percentage reduction in real GDP and also experienced the most significant reduction in real imports. More detailed inspection of these imports reveals relatively large percentage reductions in imports that face particularly high transport cost increases, including horticulture, processed foods and cereals. However imports such as manufactured products tend to contribute a particularly significant proportion of the overall value of import declines. While transport cost increases are not particularly high for this sector (see Table 1), this tends to be a very large sector, therefore even relatively small percentage declines in imports translate into large dollar value declines.

3.2.1 Change in US Trade Patterns

Turning now to the changes in trade for the United States under each scenario, Table 3 indicates that exports are lower under the first three ISPM 15 scenarios, by up to $5.2 billion or 0.48 percent in the most stringent case. However, exports increase by 0.1 percent under the fourth scenario that includes United States domestic and trade with Canada. This appears to be due to a dampened economy with reduced market prices under scenario four. This drives increased export competitiveness, more than offsetting the higher transport costs experienced by the United States.

As indicated in Table 4, total real imports for the United States are lower under each scenario, ranging from 0.05 percent in the least stringent scenario, to a 0.59 percent reduction in the most stringent policy requiring plastic pallets. Further inspection of Table 5 indicates that imports of all products (except sugar and products) decrease, though only for the most stringent policy might the reduction be considered ‘economically’ significant. There are some significant differences in real imports by commodity. In particular, for the first three scenarios the horticulture and other food preparations sectors experience particularly significant percentage declines in imports. This is perhaps not surprising, given that these sectors have the highest pallet margins and hence experience the highest transport cost increases. The largest reduction in sectoral imports is for horticultural products. This reduction in imports is predominantly from Central and South America (ranging from US$57 to US$557 million in the most stringent policy scenario), though this is partly offset by increased imports of these products from Canada (US$15 to US$165 million) and

Mexico (US$25 to US$232 million). The second largest decrease in imports is for other food preparations. The reduction in imports for this sector is predominantly from South America (US$44 to US$417 million), but there are also large reductions in imports from Asian and European regions. These reductions are partly offset by increased imports of these products from Canada (US$46 to US$571 million).

The third largest decrease is for mineral products, including tiles, which also has a relatively high pallet margin. The reduction in imports is predominantly from Southern Europe, which includes Italy (US$39 million to US$264 million), and South America. These reductions are partly offset by increased imports from Canada (US$15 to $141 million) and Mexico (US$11 to US$115 million).

For the United States, overall imports reduce under all scenarios (Table 4), however, there are significant differences by trading partner, as indicated in Table 6. Imports from many regions decrease, with the largest absolute decreases in imports from South America, East Asia and Europe and China (the most stringent policy scenario only). Across these regions, the category of other food preparations is the main product export to the United States that decreases, reflecting the high pallet margin for these products. There is a relatively large increase in United States imports from Canada and Mexico, and China in the first two scenarios. Canada increases exports to the United States of horticultural and miscellaneous pallet-using agricultural products. The increase in United States imports from Canada and China in the first three scenarios is due to no ISPM 15 policy applied (for Canada and China), or a smaller marginal effect of the policy (for China). Mexico increases exports to the United States of horticultural products.

The increase in United States imports from Canada and Mexico may be due to the relatively lower cost of shipping goods, which reduces the impact of percentage increases in shipping costs. Indeed transport margin costs relative to the value of imports into the United States are only 1.4 percent on average for imports from Mexico and 1.7 percent for imports from Canada. However, for imports from other regions, transport costs are between 2 and 7 percent of the value of imports.

China increases exports to the United States of horticultural and miscellaneous pallet-using agricultural products (across all scenarios) and mineral products for the current ISPM 15 policy. There is an increase in United States imports from China when an ISPM 15 type policy is applied domestically though the increase is less than 0.2 percent.

When the least stringent policy is also applied to United States domestic trade and trade with Canada in the final scenario, imports are lower by a very similar amount to the first scenario. Although in this final scenario, the impact on overall real imports is similar to the first scenario, with a 0.05 percent reduction (Table 4), there are some notable differences across commodities (Table 5). While imports with the highest pallet margins are particularly impacted by increases in international transportation costs, these sectors are now also impacted by relatively high increases in domestic transport margins. Therefore, imports of cereals, horticulture and processed foods are harmed less in the fourth scenario than they were in the initial ISPM 15 scenario.

3.2.2 General pest implications due to ISPM 15

An overall trend for the impact of ISPM 15 (due to varying stringencies) on the United States as applied in international trade is that it shifts imports of horticultural and other food preparations away from Central and South America and mineral products from Southern Europe, to Canada and Mexico, and to a lesser extent China. This shift in the source of imports due to ISPM 15 is related in part to higher pallet margins (proportion of transport costs associated with pallet costs) for horticultural, other food preparations and mineral products and the relatively low value of these goods. This relationship makes it more costly to ship these products longer distances, say from Central and South America as compared with from Canada and Mexico.

A change in the source country of horticultural products imported by the United States could have major pest-risk implications for the United States. First, although ISPM 15 reduces the risk of pests carried on wood packaging material, this standard does not reduce the risk of pests associated with the fruits and vegetables themselves. Second, importation of horticultural products such as guava and Haas avocados from Mexico has in the past been identified as a high-risk pathway for pest introductions (USDA APHIS 2001). For example, Mexico is a major source of U.S. interceptions of insects on fruit, with the US-Mexico land border accounting for 13 percent of plant pest interceptions between 1984 and 2000 (McCullough 2006). And lastly, given the ecological similarities between many parts of Mexico and the United States, as compared with Central and South America, then pests native to Mexico could be expected to more easily become established.

4 Tentative Conclusions

The current study has used GTAP-M to examine the impacts of implementing various ISPM 15 policies, internationally and also domestically within the US market. We find that the welfare, real GDP, and overall real trade impacts of ISPM 15 are small, even for the most stringent treatment. However, there is significant regional variation in the impact, with Polynesia, the Rest of Europe, and West Africa relatively more affected because of the higher pallet margin for their export products; processed foods, and miscellaneous pallet-using agricultural products.

The welfare, real GDP and trade impacts on the United States of ISPM 15 are very small, including when ISPM 15 is applied to domestic trade. Within this small impact though is a shift in imports of horticultural and other food preparations away from South and Central America and mineral products from Southern Europe, to Mexico, Canada and to a lesser extent China. Shifts in trading partners could have interesting implications for United States pest risk.

Of course these results should be interpreted with cautions. In particular, readers should be aware that the results are very much driven by the underlying assumptions of the model used (Hertel, 1997; Peterson 2006), the databases used (Narayanan and Walmsley 2008; Peterson et al. 2009) and the assumptions of the policy scenarios we modeled.

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Appendix 1: GTAP Sector Concordances

Sector	GTAP sectors[1]
Cereals	pdr, wht, gro
Oilseeds	osd
Sugar and products	c_b
Horticulture	v_f
Agricultural fibres	pfb, wol
Misc pallet-using agriculture	ocr, oap
Non pallet-using agriculture	ctl, rmk
Natural resources	frs, fsh
Petroleum and coal	coa, oil, gas, p_c
Minerals	omn
Meat products	cmt, omt
Oils and fats	vol
Dairy products	mil
Beverages and tobacco	b_t
Other food preparations	pcr, sgr, ofd
Textiles and leather	tex, wap, lea
Wood, pulp, paper	lum, ppp
Mineral products	nmm
Chemicals, rubber, plastics	crp
Metal products	i_s, nfm, fm
Vehicles and accessories	mvh, otn
Electronics, other manufacturing	ele, ome, ely
Trade	trd
Air transport	atp
Sea transport	wtp
Other transport	otp
Other services	ely, gdt, wtr, cns, cmn, ofi, isr, obs, ros, osg, dwe

[1] Refer to Narayanan & Walmsley (2008) for a description of the GTAP sectors

Appendix 2: GTAP regions and country codes

Region	Country codes[1]
USA	USA
Canada	CAN
Mexico	MEX
Central America	CRI GTM NIC PAN XCA
South America	ARG BOL BRA CHL COL ECU PRY PER URY VEN XSM
Caribbean	XNA XCB
Australia & NZ	AUS NZL
Polynesia	XOC
China	CHN HKG
East Asia	JPN KOR TWN XEA
SE Asia	KHM IDN LAO MMR MYS PHL SGP THA VNM XSE
South Asia	BGD IND PAK LKA XSA IRN
West Asia	CYP ARM AZE GEO TUR XWS
Central Asia	KAZ KGZ XSU
East Europe	CZE HUN POL SVK BGR BLR ROU RUS UKR XEE
North Europe	DNK EST FIN IRL LVA LTU SWE GBR NOR
West Europe	AUT BEL FRA DEU LUX NLD CHE
South Europe	GRC ITA MLT PRT SVN ESP ALB HRV
Rest of Europe	XEF XER
North Africa	EGY MAR TUN XNF
West Africa	NGA SEN XWF
Central Africa	XCF
East Africa	ETH MDG MWI MUS MOZ TZA UGA ZMB ZWE XEC
South Africa	XAC BWA ZAF XSC

[1] Refer to Narayanan & Walmsley (2008) for a description of the GTAP regions

Tables

Table 1 Percentage share of pallet value in international transport costs and percent change from base transport margin due to various scenarios of ISPM 15

		ISPM 15 scenario		
		Current	HT+[1]	Plastic pallets
Sector	Pallet margin[2]	$2.00	$2.50	$14.00
Cereals	25.2	5.6	7.0	39.2
Oilseeds	9.9	2.2	2.8	15.4
Sugar and products	14.9	3.3	4.1	23.1
Horticulture	25.2	5.6	7.0	39.2
Other agriculture	5.0	1.1	1.4	7.7
Misc pallet-using agriculture	19.8	4.4	5.5	30.8
Non pallet-using agriculture	0.0	0.0	0.0	0.0
Natural resources	1.8	0.4	0.5	2.8
Petroleum and coal	1.8	0.4	0.5	2.8
Minerals	14.9	3.3	4.1	23.1
Meat products	14.9	3.3	4.1	23.1
Oils and fats	19.8	4.4	5.5	30.8
Dairy products	14.9	3.3	4.1	23.1
Beverages and tobacco	19.8	4.4	5.5	30.8
Other food preparations	25.2	5.6	7.0	39.2
Textiles and leather	1.8	0.4	0.5	2.8
Wood, pulp, paper	9.9	2.2	2.8	15.4
Mineral products	9.9	2.2	2.8	15.4
Chemicals, rubber, plastics	9.9	2.2	2.8	15.4
Metal products	9.9	2.2	2.8	15.4
Vehicles and accessories	5.0	1.1	1.4	7.7
Electronics, other manufact.	5.0	1.1	1.4	7.7
Trade	n.a.	n.a.	n.a.	n.a.
Air transport	n.a.	n.a.	n.a.	n.a.
Sea transport	n.a.	n.a.	n.a.	n.a.
Other transport	n.a.	n.a.	n.a.	n.a.
Other services	n.a.	n.a.	n.a.	n.a.

[1] HT+ = higher heat treatment requirement

[2] pallet margin shares represent the proportion of international shipping costs that are due to pallet costs.

Table 2 Changes in equivalent variation and real GDP resulting from the four ISPM 15 scenarios modelled

	Welfare (US$m)				Real GDP (%)			
	Current	HT+	Plastic	US dom.	Current	HT+	Plastic	US dom.
USA	-586	-816	-6,971	-4,615	0.000	0.000	-0.003	-0.028
Canada	-7	4	264	-51	0.000	0.001	0.007	-0.001
Mexico	-122	-151	-918	-71	-0.004	-0.005	-0.032	-0.003
Central America	-81	-102	-709	-75	-0.012	-0.015	-0.106	-0.011
South America	-384	-484	-3,184	-327	-0.004	-0.005	-0.029	-0.003
Caribbean	-122	-155	-1,068	-113	-0.014	-0.018	-0.126	-0.013
Australia & NZ	-206	-260	-1,734	-184	-0.003	-0.003	-0.021	-0.002
Polynesia	-22	-27	-196	-21	-0.024	-0.031	-0.222	-0.024
China	-618	-844	-6,548	-560	-0.004	-0.005	-0.041	-0.004
East Asia	-1,075	-1,357	-9,192	-1,020	-0.003	-0.004	-0.028	-0.003
SE Asia	-674	-853	-5,622	-643	-0.009	-0.011	-0.077	-0.009
South Asia	-331	-419	-2,790	-317	-0.008	-0.010	-0.066	-0.008
West Asia	-503	-638	-4,326	-406	-0.005	-0.006	-0.040	-0.005
Central Asia	-31	-39	-257	-23	-0.002	-0.002	-0.016	0.000
East Europe	-586	-744	-5,005	-521	-0.009	-0.012	-0.079	-0.008
North Europe	-378	-473	-3,344	-275	0.000	0.000	-0.002	0.001
West Europe	-903	-1,137	-7,918	-793	-0.001	-0.001	-0.007	0.000
South Europe	-724	-919	-6,239	-697	-0.007	-0.009	-0.064	-0.007
Rest of Europe	-106	-135	-940	-106	-0.028	-0.036	-0.256	-0.028
North Africa	-173	-220	-1,509	-149	-0.013	-0.017	-0.116	-0.013
West Africa	-133	-168	-1,218	-113	-0.025	-0.032	-0.229	-0.023
Central Africa	-16	-20	-143	-11	-0.009	-0.011	-0.078	-0.008
East Africa	-89	-112	-795	-86	-0.015	-0.019	-0.138	-0.015
South Africa	-98	-124	-832	-87	-0.005	-0.006	-0.037	-0.004

Table 3 Changes in real exports under the four ISPM 15 scenarios

	US$m				% change			
	Current	HT+	Plastic	US dom.	Current	HT+	Plastic	US dom.
USA	-571	-752	-5,215	1,073	-0.05	-0.07	-0.48	0.10
Canada	-74	-96	-698	-119	-0.02	-0.03	-0.21	-0.04
Mexico	47	58	440	47	0.02	0.03	0.23	0.02
Central America	-7	-9	-67	-10	-0.02	-0.03	-0.21	-0.03
South America	-183	-233	-1,557	-213	-0.06	-0.08	-0.55	-0.08
Caribbean	31	40	280	28	0.07	0.08	0.59	0.06
Australia & NZ	-47	-60	-392	-68	-0.03	-0.04	-0.29	-0.05
Polynesia	0	0	2	0	0.00	0.00	0.03	0.00
China	-528	-714	-5,218	-555	-0.06	-0.09	-0.63	-0.07
East Asia	-325	-416	-2,309	-489	-0.03	-0.03	-0.19	-0.04
SE Asia	18	23	94	-32	0.00	0.00	0.02	-0.01
South Asia	-141	-179	-1,166	-155	-0.08	-0.10	-0.62	-0.08
West Asia	-209	-265	-1,831	-263	-0.05	-0.06	-0.40	-0.06
Central Asia	-17	-22	-150	-20	-0.05	-0.06	-0.43	-0.06
East Europe	-341	-435	-2,876	-374	-0.06	-0.08	-0.54	-0.07
North Europe	-190	-241	-1,522	-268	-0.02	-0.02	-0.14	-0.02
West Europe	-464	-592	-3,834	-615	-0.02	-0.03	-0.17	-0.03
South Europe	-306	-390	-2,551	-380	-0.04	-0.05	-0.32	-0.05
Rest of Europe	71	91	621	70	0.38	0.48	3.26	0.37
North Africa	-38	-49	-363	-58	-0.04	-0.05	-0.35	-0.06
West Africa	-1	-1	0	-11	0.00	0.00	0.00	-0.02
Central Africa	-4	-5	-42	-8	-0.03	-0.03	-0.30	-0.06
East Africa	-12	-15	-142	-14	-0.04	-0.05	-0.46	-0.05
South Africa	-46	-59	-407	-55	-0.05	-0.07	-0.47	-0.06

Table 4 Changes in real imports under the four ISPM 15 scenarios

	US$m				% change			
	Current	HT+	Plastic	US dom.	Current	HT+	Plastic	US dom.
USA	-783	-1,120	-9,808	-777	-0.05	-0.07	-0.59	-0.05
Canada	-15	-6	208	-85	0.00	0.00	0.07	-0.03
Mexico	-117	-143	-811	-65	-0.06	-0.08	-0.43	-0.03
Central America	-90	-114	-787	-84	-0.24	-0.31	-2.11	-0.23
South America	-521	-658	-4,329	-465	-0.25	-0.32	-2.09	-0.22
Caribbean	-138	-175	-1,183	-125	-0.21	-0.27	-1.83	-0.19
Australia & NZ	-246	-311	-2,050	-222	-0.16	-0.21	-1.37	-0.15
Polynesia	-24	-30	-212	-23	-0.20	-0.25	-1.78	-0.19
China	-957	-1,311	-10,025	-917	-0.14	-0.19	-1.42	-0.13
East Asia	-1,280	-1,614	-10,134	-1,190	-0.13	-0.16	-1.03	-0.12
SE Asia	-704	-892	-5,790	-702	-0.13	-0.16	-1.07	-0.13
South Asia	-409	-519	-3,381	-392	-0.18	-0.23	-1.51	-0.17
West Asia	-725	-921	-6,156	-655	-0.18	-0.22	-1.49	-0.16
Central Asia	-49	-62	-404	-44	-0.17	-0.21	-1.39	-0.15
East Europe	-875	-1,113	-7,380	-838	-0.18	-0.22	-1.48	-0.17
North Europe	-502	-630	-4,099	-393	-0.05	-0.06	-0.39	-0.04
West Europe	-1,222	-1,542	-10,183	-1,081	-0.06	-0.07	-0.46	-0.05
South Europe	-808	-1,027	-6,779	-761	-0.09	-0.12	-0.76	-0.09
Rest of Europe	-105	-134	-924	-104	-0.33	-0.42	-2.88	-0.32
North Africa	-232	-294	-1,996	-211	-0.25	-0.32	-2.15	-0.23
West Africa	-122	-154	-1,092	-109	-0.23	-0.29	-2.07	-0.21
Central Africa	-22	-28	-193	-17	-0.24	-0.30	-2.07	-0.19
East Africa	-101	-129	-920	-98	-0.26	-0.33	-2.33	-0.25
South Africa	-161	-204	-1,362	-146	-0.20	-0.26	-1.72	-0.18

Table 5 Impact of ISPM 15 policies on the United States real imports, by commodity

	%				US$m			
	Current	HT+	Plastic	US dom.	Current	HT+	Plastic	US dom.
Cereals	-0.28	-0.37	-3.18	0.58	-1.9	-2.6	-21.8	4.0
Oilseeds	-0.32	-0.45	-3.46	-0.58	-1.6	-2.3	-17.5	-2.9
Sugar and products	0.17	0.20	1.19	0.20	0.0	0.0	0.1	0.0
Horticulture	-0.63	-0.80	-6.03	-0.01	-61.8	-78.9	-595.6	-0.6
Other agriculture	-0.11	-0.15	-1.25	-0.39	-0.2	-0.2	-2.0	-0.6
Misc pallet-using agriculture	-0.33	-0.42	-3.30	-0.22	-27.7	-35.8	-278.4	-18.8
Non pallet-using agriculture	-0.15	-0.20	-1.87	-0.45	-1.3	-1.8	-16.6	-4.0
Natural resources	0.00	0.00	-0.03	-0.08	0.0	-0.1	-0.6	-1.8
Petroleum and coal	0.00	0.00	-0.01	0.16	-5.5	-6.9	-21.1	293.2
Minerals	-0.11	-0.15	-1.23	0.09	-5.7	-7.5	-62.3	4.6
Meat products	-0.25	-0.32	-2.46	-0.18	-16.5	-21.4	-163.3	-12.1
Oils and fats	-0.31	-0.40	-3.15	0.22	-7.7	-10.0	-79.1	5.4
Dairy products	-0.28	-0.35	-2.63	-0.29	-7.0	-8.9	-66.3	-7.3
Beverages and tobacco	-0.18	-0.23	-1.74	-0.17	-24.2	-30.8	-236.1	-22.6
Other food preparations	-0.41	-0.54	-4.77	-0.25	-120.8	-158.4	-1,408.3	-72.9
Textiles and leather	0.01	0.01	0.04	-0.06	15.8	16.7	49.3	-75.8
Wood, pulp, paper	-0.18	-0.26	-2.13	-0.12	-137.7	-200.6	-1,670.3	-95.7
Mineral products	-0.42	-0.57	-3.95	-0.17	-83.6	-112.5	-780.9	-33.8
Chemicals, rubber, plastics	-0.12	-0.17	-1.29	0.00	-182.1	-250.0	-1,903.6	-6.8
Metal products	-0.15	-0.21	-1.61	-0.03	-131.9	-183.6	-1,426.0	-29.7
Vehicles and accessories	-0.01	-0.02	-0.22	-0.07	-35.4	-55.5	-536.3	-166.3
Electronics, other manufact.	-0.01	-0.02	-0.25	-0.09	-53.5	-102.3	-1,175.9	-446.1

Table 6 Impact of ISPM 15 policies on the value of United States imports (at market prices), by region of origin

	%				US$m			
	Current	HT+	Plastic	US dom.	Current	HT+	Plastic	US dom.
Canada	0.07	0.1	0.67	0.02	171.8	228.6	1,650.4	55.3
Mexico	0.06	0.1	0.61	0.07	97.7	126.4	951.6	114.9
Central America	-0.14	-0.2	-1.19	-0.09	-20.3	-24.8	-168.0	-13.0
South America	-0.23	-0.3	-1.72	-0.12	-186.2	-229.6	-1,398.9	-100.7
Caribbean	-0.15	-0.2	-0.97	-0.10	-21.6	-26.6	-138.7	-13.7
Australia & NZ	-0.15	-0.2	-1.07	-0.13	-25.2	-30.7	-182.5	-22.1
Polynesia	-0.24	-0.3	-1.96	-0.25	-2.7	-3.3	-21.5	-2.7
China	0.18	0.1	-1.24	0.17	402.6	275.9	-2,752.3	374.6
East Asia	-0.10	-0.1	-0.54	-0.13	-233.3	-273.3	-1,317.2	-309.1
SE Asia	-0.05	-0.1	-0.09	-0.05	-50.0	-51.2	-86.3	-51.2
South Asia	-0.08	-0.1	-0.38	-0.11	-23.9	-28.0	-117.5	-34.2
West Asia	-0.04	0.0	-0.23	0.04	-29.4	-33.0	-164.6	26.1
Central Asia	0.02	0.0	0.21	0.03	0.2	0.3	2.7	0.3
East Europe	-0.17	-0.2	-1.10	-0.11	-50.5	-60.7	-330.4	-32.7
North Europe	-0.16	-0.2	-1.12	-0.16	-222.3	-271.2	-1,548.7	-221.0
West Europe	-0.21	-0.3	-1.47	-0.22	-416.8	-511.5	-2,942.6	-435.9
South Europe	-0.38	-0.5	-2.78	-0.35	-221.0	-273.5	-1,624.8	-205.7
Rest of Europe	0.45	0.6	4.09	0.46	6.8	8.7	61.0	6.9
North Africa	0.02	0.0	0.20	0.09	3.0	4.1	30.6	14.0
West Africa	0.03	0.0	0.34	0.14	4.5	6.2	56.9	23.1
Central Africa	0.00	0.0	0.02	0.09	-0.2	-0.1	1.0	4.0
East Africa	0.24	0.3	2.26	0.25	8.8	11.2	81.5	9.0
South Africa	0.03	0.0	0.47	0.11	3.2	5.2	59.7	13.8