Study of the Possible Effect of Problem Drywall Presence on Foreclosures

Report to Congress

July 17, 2012

Summary Overview

This report is HUD's response to section 1494 of the Dodd-Frank Act, which required the Secretary of Housing and Urban Development, in consultation with the Secretary of the Treasury, to conduct a study of the effect on residential mortgage loan foreclosures of: (1) the presence in residential structures subject to such mortgage loans of drywall that was imported from China during the period beginning with 2004 and ending at the end of 2007; and (2) the availability of property insurance for residential structures in which such drywall is present. The report begins by providing context and background information regarding drywall imported from China, its presence in the U.S. homebuilding market, and the recent problems associated with it. It then calculates the extent of possible impacts associated with problem drywall by estimating of the number of residences built with drywall imported from China, the geographic distribution of these units, and the fraction of units affected. Following this assessment of scope and scale, the report examines how the presence of problem drywall might catalyze a foreclosure. This section includes discussion of the indirect consequences of problem drywall, the primary causes of foreclosure in the U.S. housing market, and whether property insurance mitigates the problems caused by some of the Chinese drywall. The report concludes with recommendations and a summary of key findings.

Key Findings. While a significant issue for those with problem drywall in their homes, problem drywall was not a significant contributor to the foreclosure crisis in the United States. Problem drywall imported from China was most likely used in the construction of approximately 11,000 new homes. While preliminary estimates indicated the imported drywall could have been used to construct an estimated 25,000 to 31,000 homes, further analysis revealed that not all drywall from China was problematic, reducing the figure to approximately 11,000 homes affected. This

is HUD's best estimate, as it incorporates non-public data compiled by the U.S. Consumer Product Safety Commission as part of their study on the drywall problem. Given that there were approximately 1.2 million foreclosure completions (REOs) during 2007 and 2008, as well as others in process at other times, drywall could have been responsible for less than 1 percent of foreclosures since the foreclosure crisis began. Even in places where the problems were concentrated, such as Florida, the fraction of foreclosures potentially caused by problems associated with drywall is quite low. Finally, although the presence of problem drywall is not a significant factor in the nation's foreclosure crisis, it is enough of a detriment to potentially trigger foreclosure among the Americans who own these homes.

Background and Origins of the Issue

Drywall, also known as gypsum board, wallboard, and sheetrock, is manufactured from gypsum ($CaSO_4 \cdot 2H_2O$), a soft, semi-water-soluble, crystalline mineral that can either be mined or synthetically produced. This common interior construction material is made by mixing gypsum with water to form a plaster that gets pressed into boards between sheets of paper. Manufacturers produce drywall of various sizes to accommodate different construction needs, with a ½-inch thickness employed most typically in residential buildings. Market demand for drywall surged in 2006, fueled by both a nationwide boom in residential construction and the need for extensive post-hurricane reconstruction along the Gulf Coast.[1] While drywall produced in the United States, Mexico, and Canada had typically met market demand, the supply pressures in 2006 caused users to import a relatively large amount from China and increase imports from still other countries. As shown in Figure 1 and Table 1, 2006 was the only year that a substantial amount – 218,100 metric tons – of drywall was imported from China. This surge occurred in part because, at that point, Chinese drywall was not considered to be fundamentally different from drywall produced elsewhere. As a consequence, a large number

[1] Notable events were Hurricane Charley in 2004 and Hurricanes Katrina, Rita and Wilma in 2005.

of builders turned to drywall from China to avoid delays in construction that would have arisen otherwise.

Some of the drywall imported from China during this period has since been discovered to be problematic due to its ability to corrode metal in homes. Some have complained of odors due to drywall emissions, sometimes comparing the odor to the smell of rotten eggs.[2] In addition to being malodorous, hydrogen sulfide gas emitted by problem drywall can also corrode a variety of metals, including copper and silver found in personal items in most homes such as silverware, jewelry, and various electronic appliances, devices, and fixtures. Although results from scientific testing conducted by the U.S. Consumer Product Safety Commission (CPSC) do not currently support a finding that corrosion of electronic building components constitutes a safety hazard to building occupants, CPSC continues to investigate this matter.[3] Some residents of homes containing problem drywall have complained of respiratory and other health-related problems associated with the problem drywall. The staff of the CPSC and the Centers for Disease Control and Prevention (CDC) agree that the levels of sulfur gases detected in the affected homes in the fifty-one home study conducted for CPSC (Environmental Health & Engineering, 2010) were at concentrations below the known irritant levels in the available scientific literature; however, it is possible that the additive or synergistic effects of these and other compounds in the subject homes could potentially cause irritant effects to consumers.[4]

While a few dozen or so cases of drywall having this emissions problem have been alleged to be linked with drywall produced in the United States, most of the problems are associated with

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[2] The CPSC asked Lawrence Berkeley National Laboratories (LBNL) to analyze emissions from thirty drywall samples. That analysis found that "the top ten reactive sulfur emitting samples were of Chinese origin. Certain Chinese samples had emission rates of hydrogen sulfide one hundred times greater than non-Chinese samples." This and other work initiated by the CPSC supports "the preliminary conclusion that: certain Chinese drywall emits reactive hydrogen sulfide at rates much higher than other, non-Chinese drywall, and that hydrogen sulfide has a strong association to corrosion in homes with problem drywall." (U.S. CPSC, April 2, 2010)

[3] For this study, the terms sulfur and sulfide are assumed to include the various corrosive sulfur compounds that might be formed as a result of the emissions from the contaminated drywall.

[4] http://www.cpsc.gov/info/drywall/faqs.html

the presence of Chinese drywall.[5] The CPSC had, as of October 15, 2010, received 3,650 reports concerning problem drywall across 38 states, the District of Columbia, Puerto Rico, and American Samoa (Table 2). Figure 2 shows that, despite the wide geographic dispersion of complaints, the drywall problem is concentrated in a small number of southern states. Two states, Florida and Louisiana, account for more than 75 percent of all complaints, and just five states (adding Mississippi, Alabama, and Virginia) account for more than 92 percent of all complaints. This geographic distribution is due in large part to the distribution of Chinese drywall imports. As shown in Table 3, 70 percent of all Chinese drywall imports flowed through Florida, and another 16 percent entered the United States through New Orleans, LA and Mobile, AL.

Problem Drywall – Estimating the Possible Impact

In order to estimate the potential impact of the drywall problem on the foreclosure crisis, one must: (1) quantify the number of units constructed, either completely or partially, with drywall imported from China; (2) calculate the subset of those units likely to have a problem; and (3) determine the likelihood that such problems would lead to a property entering the foreclosure process, from which one can estimate the number of homes with a drywall problem likely to enter foreclosure. This final estimate can then be compared to the overall number of foreclosures. The following sections detail processes that produce estimates of each of these, after which they are combined to estimate the aggregate impact of the drywall problem on the foreclosure crisis.

Estimated Number of Units Constructed with Drywall Imported from China

Section Summary. Using data drawn from multiple sources, the volume of drywall imported from China between 2004 and 2007 is estimated to have been enough to construct as many as 31,000 homes, but more likely was used to construct no more than 25,000 homes. Note that not all drywall imported from China is problematic, so the subset of units with problem drywall

[5] For example, the Lowe's settlement (Lamden, 2010) concerned domestic drywall cases.

(approximately 11,000 based on our primary estimate and covered in the next section) is less than the total number of units constructed with Chinese drywall.

Analysis. China's share of the drywall imported to the United States is quite small, with the amount being negligible in most years (Table 1). The lone exception is 2006, when the share from China, in metric tons, represented 22 percent of the total drywall imported into the United States and 1.7 percent of all ½-inch drywall used in the U.S. in 2006. In total, between 2004 and 2007, 230,850 metric tons of drywall was imported from China, representing 8 percent of all drywall imported and 0.5 percent of all ½-inch drywall used in the U.S. over that time.[6] Assuming that the drywall weighs 1.7 pounds per square foot[7] (USGS, 2000), this volume of Chinese drywall translates to approximately 299 million square feet of drywall available for use in the United States.

Recent national surveys of the quantity of drywall used for home construction can be used to estimate the average amount of drywall used in a typical new single-family detached home. The results of two surveys conducted by the National Association of Home Builders suggest that about 3.7 square feet of drywall is used for every square foot of living space in the United States (table 4). As about 85 percent of the drywall imported from China was used in southern states, it is most appropriate to apply this ratio to the average size of houses in the South to estimate the number of units that could have been constructed using drywall imported from China. According to the United States Census Bureau, the median floor area of a new single-family home completed in the South in 2006 was 2,286 square feet. This implies that the typical southern home would use 8,487 square feet of drywall. Thus, the nearly 299 million square feet of drywall imported from 2004 to 2007 could have been used to construct almost

[6] The Department does not have data concerning different types of drywall imported from China. The figures on drywall imported from China as a percentage of all ½ inch drywall sold in the United States are calculated under the analytically conservative (i.e., high) assumption that all Chinese drywall is ½ inch drywall.
[7] Using an industry standard of 1.7 pounds per square foot of ½-inch drywall; a metric ton equates to 1,300 square feet.

35,000 homes if one assumes that only ½-inch drywall imported from China was used in each home.

Finally, some drywall is trimmed and discarded during the construction process. By one recent estimate, about 12 percent of drywall is lost as waste (California Department of Resources Recycling and Recovery, 2007). Incorporating this into the previous estimates, approximately 31,000 entire homes could have been constructed from drywall imported from China.

It is arguable that the figure of 31,000 homes represents an upper bound estimate of the number of recently built homes containing drywall imported from China. One possible argument is that not all of the drywall imported from China may have been used in construction. As soon as the problem associated with some drywall became known, builders would have been reticent to buy drywall produced in China regardless of its quality. However, this argument does not apply to the vast majority of Chinese drywall because most of drywall was imported in 2006 and months elapsed before the problems were noticed by homeowners. From its study of the drywall supply chain, the CPSC estimates that 18 percent of all drywall imports from China were either damaged in transport to the United States or remained unused in warehouses.[8] Thus, only 82 percent of the drywall imported from China would have been used in the construction of homes, which reduces the ceiling of 31,000 potential homes affected to 25,000 (0.82 X 31,000). Two primary estimates of the number of houses built with drywall imported from China are presented throughout the analysis: (1) an "upper estimate" of 31,000 homes based entirely on publicly available data and (2) a "lower estimate" of 25,000 homes incorporating information received from the CPSC. The estimate of 25,000 (and 31,000) represents the potential number of homes built with drywall imported from China, whereas the number of homes with problem drywall will be smaller because not all Chinese drywall is problem drywall.

[8] CPSC staff communicated this result concerning damaged and stockpiled drywall in an email to HUD staff on March 28, 2011.

Another argument for viewing these as upper bound estimates is that drywall is used in a variety of product types not limited to residential uses, such as office, industrial, and retail properties. If some of the drywall imported from China between 2004 and 2007 was used for purposes other than residential construction, then the estimate of 25,000 (or upper estimate of 31,000) homes would might overstate the extent to which drywall imported from China is present in homes in the U.S. and understate its presence in other structures. However, estimates of the proportion of drywall produced for residential construction are based on the thickness of the board. The overwhelming majority of residential construction uses ½-inch board, which is not used commonly in other types of construction.[9] Although HUD does not have access to data on imports by type of drywall, some experts believe that a majority of the drywall imported from China was ½-inch for residential construction. Consistent with this view, there have been few complaints of problem drywall in office or retail buildings.[10] Thus, it is not likely that a significant amount of problem drywall was diverted to non-residential construction.

On the other hand, some estimates place the number of homes with problem drywall in them at almost 100,000.[11] Given construction fundamentals reviewed above, this number seems implausible based on the amount of drywall imported from China into the U.S. That noted, one possible justification of a larger estimate is that the construction of a home might involve drywall imported from China in conjunction with drywall from other sources. If this were true, then the 25,000 (or 31,000) homes would be a lower bound estimate of the number of homes with drywall imported from China in them.[12]

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[9] Commercial construction uses primarily 5/8" for additional soundproofing and to satisfy fire safety codes (International Code Council, 2009).

[10] This could potentially also be the result of larger office or retail room areas (and volumes) which significantly reduce the drywall to floor area ratio.

[11] However, according to the originator of the 100,000 estimate, the methodology was "unscientific" (Marsteller, 2009).

[12] An argument for a potentially larger number of affected homes stems from the requirements to repair homes damaged by disasters, where only some walls or ceilings must be replaced. This would have applied more following Hurricane Charley in 2004 where there was minimal flooding than Hurricane Katrina in 2005 where homes that flooded typically had all drywall replaced.

Unfortunately, there has been no scientific survey to determine the typical pattern of how drywall imported from China has been used in home construction, whether used exclusively for a given home or in combination with other drywall sources.[13] Because of the widespread use of specialty drywall subcontractors in residential construction, most homes receive all drywall at a single time from one supplier rather than from multiple suppliers. Given the high cost of transporting drywall, contractors may not have the option of choosing among many different suppliers. Using one shipment from the same supplier is also easier because drywall must be installed as quickly as possible to avoid damage. It is also less burdensome to do business with one supplier than with many. These arguments suggest a lower likelihood of mixing Chinese drywall and drywall manufactured in other countries; it is likely that Chinese drywall is concentrated in fewer homes. Although the total number of homes with Chinese drywall is likely far less than 100,000, one must acknowledge that more homes may have drywall imported from China in them than the preliminary estimate of approximately 25,000 (or upper estimate of 31,000) homes built with drywall imported from China.

Thus, there remains considerable uncertainty regarding the number of homes that have drywall imported from China in them. Lacking data to rationalize either a higher estimate if partial construction patterns prevailed or some lower estimate if some of the problem drywall was used for non-residential construction in any volume, the remainder of the analysis will use the lower and upper estimates of 25,000 and 31,000 homes containing drywall imported from China as a baseline. In considering the ensuing analysis, readers should remain cognizant of the fact that this number is an estimate and the issues that could make the true presence either larger or smaller.[14]

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[13] As a consequence, some have discounted the estimate of 100,000 as an "unscientific" estimate (Marstellar, 2009).

[14] The reader should be assured by the fact that another careful estimate arrived at a roughly similar result: the U.S. Geological Survey estimated that 38,000 were built from drywall imported from China between 1999 and 2008 (U.S. Geological Survey, 2008).

Estimated Subset of Units with Problem Chinese Drywall

Section summary. Not all homes that have Chinese drywall should be expected to have a drywall problem. Based on information from the CPSC,[15] a problem is associated with about 43 percent of the drywall imported from China. Therefore, HUD's primary estimate of the number of homes with problem drywall is 11,000.

Analysis. CPSC staff, who have been leading research of drywall imports since the onset of the first reports received of problem drywall, estimate that 43 percent of the drywall imported from China is problematic.[16] This estimate was the result of combining information from a variety of sources, some of which are non-public: import records by manufacturer, measurement by the Lawrence Berkeley National Laboratories of sulfur compound emission rates by manufacturer, consumer incident reports, and hundreds of other reports made to the CPSC from builders, suppliers, distributors, importers, and others, which the CPSC has collected in their two year investigation of problem drywall. Applying this ratio to the lower estimate of the stock of 25,000 homes built with drywall imported from China, the number of homes with problem drywall is estimated to be 11,000. Note that this estimate relies upon data that are not public.

An alternative estimate of the percentage of problem drywall could be derived from publicly available information. Laboratory tests conducted by the CPSC in the wake of claims of problems have definitively shown a difference in sulfur compound emissions between Chinese-manufactured drywall and North American-manufactured drywall only some of the time (CPSC, May 2010). In these tests, examiners compared nine Chinese drywall samples manufactured in 2005 and 2006 with 13 North American drywall samples manufactured in 2009 in terms of the level of sulfur compound emissions and the reactivity of these emissions. Seven of the nine Chinese drywall samples produced in 2005 and 2006 were found to emit more reactive sulfur

[15] CPSC staff communicated this information to HUD staff in an email dated March 28, 2011.
[16] The equivalence of the frequency of problems arising to the proportion of ½ inch drywall produced domestically (2004-2007) is coincidental. This result was communicated in an email to HUD staff in an email on March 28, 2011.

compounds than their North American counterparts, while two showed only minimal differences.[17] A separate test of Chinese drywall samples from 2009 showed that the later Chinese drywall emitted less sulfur compounds than the 2005 and 2006 samples.[18] Based on tests conducted on drywall used during the 2004 through 2007 period, one should not expect all of the drywall imported from China during 2004 through 2007 to have a problem.

These tests clearly show a range of sulfur compound emissions among the drywall imported from China within the 2005-2006 cohort. If one were to take the results of the test as a general pattern, then one would expect problems with Chinese drywall about seven-ninths, or 78 percent, of the time. However, the small number of the samplemeans that the percentage is not particularly precise; see below for further discussion of the percentage. While a high percentage, the estimate of seven-ninths implies that it is possible that not all of homes containing drywall from China will have a problem.[19] One could thus pro-rate the upper estimate of the number of homes built from Chinese drywall (31,000) using this percentage to estimate that 24,000 homes were constructed with problem drywall. This figure of 24,000 represents the upper estimate of problem homes derived from publicly available data. This validity of this estimate of seven-ninths is weakened, however, by the Department's lack of knowledge concerning the share of imports attributable to the manufacturers of problem drywall, which would result in a lower estimate.

The true percentage of problem drywall found in homes built from drywall imported from China is probably smaller than the unweighted, laboratory-measured 78 percent, and closer to the CPSC's estimate of 43 percent. First, the samples collected for analysis were not necessarily

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[17] Environmental Health & Engineering, 2010.

[18] Including the drywall samples from 2009 would lower the estimated proportion of problem drywall imported from China to 56 percent and the units affected would be 17,000. However, doing so would be misleading because no drywall was imported from China in 2009.

[19] According to Environmental Health and Engineering (2010): "at this time there is insufficient evidence to support or refute the assertion that all Chinese-origin or imported drywall exhibits the health or corrosive characteristics reported in complaint homes."

designed to be representative of the housing stock built with drywall imported from China during 2004 to 2007. Instead, the drywall samples were collected by CPSC staff from different manufacturers, drywall suppliers, and storage warehouses. Second, the number of observations is small, and not necessarily representative of the proportion of different manufacturer's drywall among imports from China or their subsequent installation in houses. While a small sample size is sufficient to study the chemical properties of drywall, it is not alone sufficient for generalizing the incidence of problem drywall among Chinese imports to the housing produced with drywall imported from China. The incidence (i.e., percentage) of problem drywall may be very similar in the nine samples from China (2005-2006) and the estimated 24,000 homes built from problem drywall (2004-2007). However, the actual percentage is not likely to be identical, and is probably much lower. The calculation of the higher and lower (primary) estimates of homes with problem drywall is summarized in Table 6.

Estimating Impact: Can a Drywall Problem Trigger Foreclosure?

An important first order question is whether a drywall problem could trigger a foreclosure. To answer this question, one must understand the drivers of default and foreclosure. Default and foreclosure typically arise[20] when: (1) homeowners have negative equity (the value of the home is less than the outstanding principal balance on the mortgage); and (2) homeowners experience a reduction in income and wealth due to the loss of a job or an event such as a medical emergency that makes making monthly mortgage payments difficult. This is often known as a "double trigger."

Regarding the first of these triggers, a simple interpretation of finance theory might lead one to predict default and foreclosure when a household immediately enters a negative equity situation, such that default occurs when the household's mortgage principal is $1 greater than the value of the house, regardless of whether the homeowner can afford to continue making the mortgage payment. This is known as strategic, or ruthless, default.[21] However, most argue

[20] U.S. Department of Housing and Urban Development, January 2010. .
[21] U.S. Department of Housing and Urban Development, January 2010.

that the level of negative equity must exceed some threshold before default and foreclosure become a possibility.[22] Strategic default is not common for several reasons.[23] Households always need shelter, and defaulting induces costs of search and disruption of established patterns of living. Families also often expect that housing values will rebound, and thus interpret a relatively small negative equity situation as temporary.

Foote et al (2008) examined data on homeowners in Massachusetts over a 20-year period and found that only 6.4 percent of homeowners with negative equity entered foreclosure. Bhutta et al. (2010) found that the median borrower does not strategically default, but rather defaults only after equity falls to negative 62 percent of their home's value, yielding a loan to value ratio of 162. Similarly, Guiso et al. (2009) found that no households would default if the equity shortfall was less than 10 percent of the value of their home. By contrast, 17 percent of the households surveyed report that they would default when the equity shortfall is 50 percent of the value of the home. On balance, economic theory and prevailing evidence suggest that negative equity alone (except in extreme cases) is unlikely to trigger foreclosure.

Rather, some income shock in addition to falling house prices is generally needed to cause default or foreclosure in most cases (Vandell, 1995; Elmer and Seelig, 1999). As one example that offers empirical support for this view, Bhutta et al (2010) found that 80 percent of the defaults in his sample of non-prime loans were generated by income shocks.[24]

In considering the drywall problem in this context, a problem drywall incident may satisfy the characteristics of a double-trigger event as it involves both a significant decline in house value and a potentially significant income shock. Regarding the decline in value, the standard appraisal paradigm for evaluating the economic damage inflicted upon environmentally

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[22] Bhutta et al., May 2010

[23] U.S. Department of Housing and Urban Development, January 2010.

[24] Given the large declines in home prices during the current housing downturn, some have tried to estimate the frequency of strategic defaults. Guido et al (2009) estimate that 26 percent of defaults are strategic. A question of continuing interest is by just how much the home value needs to fall before a homeowner will consider ruthless default.

contaminated real estate is the difference between its problem-free value clean and its value when it has a problem: $V_c - V_d$ = damage (Mundy, 1992). This damage represents the decline in value, because a prospective buyer would only be willing to pay a price equal to the problem-free value less the damage, so as to be whole post-remediation.

For the drywall problem, there is general agreement among courts and regulators, and among others, that the only guaranteed mode of remediation is to replace all of the problem drywall in houses containing it (Lamden, 2010). Therefore, a straightforward means of computing the impact of the problem is to determine the "cost to cure" by implementing these renovations. In this case, the cost to cure the drywall problem is the cost to completely remove problem drywall and corroded fixtures and install new drywall as well as new fire safety alarms, some electrical components, and gas service piping. It would also include the cost of relocating the homeowner while the work is done, and any other incidentals.

Several media reports have cited $100,000 as an appropriate estimate of the cost to cure homes built using problem drywall (Allen, 2009; Clark, 2010; Martin, 2010). This amount is consistent with the $80.7 million set aside by the Lennar Corporation to assist the rebuilding of 900 homes at an average of $89,700 per home (Wotapka and Whelan, 2010). In addition, Lowe's has reached an out of court settlement that may provide $100,000 in cash to all households with problem drywall purchased from one of the company's retail outlets (Sapien and Kessler, 2010). Finally, the National Association of Home Builders (NAHB) has recently testified before Congress that it would probably cost between one-third of a home's value and up to $100,000 to repair (Mowbray, 2009). While these three independent pieces of evidence converge on a common cost to cure estimate of $100,000, it is useful to conduct more formal analysis to produce an estimate.

The median price of a new home in the first quarter of 2010 was $222,900 (U.S. Department of Housing and Urban Development, 2010). The price-proportional method – namely NAHB's estimate of one-third of a home's value – yields an average estimated cost of $72,600. Another consultant for the construction industry puts the cost at 50 to 55 percent of the cost of construction (NAHB, March 2010), and the average cost of construction per square foot in 2009

was $83.89 for the United States as a whole and $76.77 for the South (NAHB, June 2010). This suggests a nationwide average cost to cure of $42 to $46 per square foot or $38 to $42 per square foot in the South, where construction costs are a bit lower. Applying these estimates to an average size of 2,400 square feet yields an estimated cost of remediation that ranges from $101,000 to $111,000 nationwide and from $92,000 to $101,000 in the South. Alternative estimates of the cost of cure are based on floor space and vary between $40 and $60 per square foot (Burdeau, 2010). Using these estimates, the estimated cost of remediation for the same 2,400 square foot home ranges from $96,000 to $144,000. The estimates based on square footage do not include the cost of relocating a household and are limited to the cost of repair. Even using a slightly smaller figure of 2,286 square feet, the median floor area of a newly built home in the South in 2006 (Census, 2009), the estimated range of the cost to cure still comes out centered roughly on $100,000.

Dealing with the drywall problem can also constitute a negative and unexpected income shock. The costs in this instance consist primarily of additional housing costs incurred as a result of relocating homeowners, but they may also include healthcare costs. As an example, the American Community Survey indicated the median annual rent in 2009 was $10,100 in the United States and $11,400 in Florida. [25]Estimates of the length of a drywall remediation are from four to six months (McQueen, April 9, 2010). These supplemental housing costs are not an insignificant burden: the median income of owner occupants during 2009 was $63,300 nationally and $53,600 in Florida, so the cost of renting alternative living quarters for six months represents as much as 16 to 20 percent of pre-tax monthly income during the remediation (or a total ranging from $5,000 to $5,700).

Given the information on the costs of remediation, one can conclude that the incidence of problem drywall could trigger default. The $100,000 remediation cost represents a 46.1 percent decline in value for the median house (which is valued at $217,000). The scenario is

[25] Annual rent was assumed to equal twelve times the monthly rent. Figures for monthly rent are available from the 2009 American Community Survey; the median monthly gross rent for the U.S. was $842 per month $952 and for Florida.

worse for the maximum cost estimate of $144,000, which would represent 66 percent of the average home's value. Assuming a loan to value (LTV) ratio of 80 percent for the median home, a remediation cost of $110,000 would be sufficient to surpass the critical default trigger LTV ratio of 162 percent found by Bhutta et al (2010). Even if the cost of remediation were lower, note that the cost of remediation would add to the decline in home value already caused by the downturn in the housing market during 2007.[26] If the incidence of problem drywall does not cause a default on its own, it could easily become one of many contributing causes.

Can the incidence of problem drywall cause a double-trigger event default? The impact will depend upon the financial resources of the household. For some, rent and relocation may be a relatively small expense. For lower-income households, however, the share of the household budget devoted to housing is much greater than for higher income households.[27] Lower-income households appear to handle the problem by tolerating the odor; ventilating when the HVAC system hasn't been corroded; or staying with friends or relatives until the home is remediated (Martin, 2010; McQueen, 2009). However, in cases where the noxious effects of the problem drywall are extreme, a household may not have much of a choice except to relocate. Even when they try to do so in a cost-minimizing fashion, these households incur housing costs beyond the cost of remediation, thereby increasing the probability of strategic default for households of all levels of income.

There are two fundamental points to be taken from this discussion:

- The reduction in home value as a result of problem drywall is significant enough to cause a default; and
- Not all homeowners should be expected to default.

[26] Home prices fell by 9.8 percent during 2007 in Florida as measured by the FHFA index.

[27] In 2009, 66 percent of renter households earning from $20,000 to $34,999 paid more than 30 percent of their earnings on housing, while for renter households earning $75,000 and greater, only 5 percent spent more than 30 percent of their income on housing (US Census, American Community Survey).

Table 5 illustrates the number of foreclosures as a result of problem drywall given different default rates for the upper and lower estimates of the total homes built from problem drywall. The maximum number of foreclosures directly caused by problem drywall would occur if all homes built with problem drywall were foreclosed upon. For the lower and primary estimate of problem homes, the maximum number of foreclosures would be 11,000 nationwide and 7,400 in Florida. For the upper estimate of problem homes, the maximum number of foreclosures would be 24,000 nationwide and 16,000 in Florida. As mentioned, it is unlikely that all homeowners will default and be foreclosed upon. An extremely high foreclosure rate of 50 percent leads to estimates of 5,500 - 12,000 and 3,700 - 8,200 foreclosures directly caused by problem drywall for the nation and Florida, respectively. Even a foreclosure rate of 10 percent is relatively high when compared to the foreclosure rate on other loans; the foreclosure inventory rate for all loans in the U.S. was 2.5 percent in the first quarter of 2008 and 4.6 percent in Florida (Mortgage Bankers Association, 2008). If the number of homes affected by problem drywall is greater than the estimate of 11,000 to 24,000, then the resulting foreclosures may also be greater than the estimates presented.

One variable that may influence the effect of problem drywall on foreclosure is the manner in which the problem drywall is distributed among homes (partial versus full construction). The effect of a substantial amount of problem drywall concentrated in a few homes can be expected to cause more defaults than a slight amount of such drywall dispersed over many homes. A household may be able to withstand an incremental loss to the value of its home, but not a more significant reduction in equity. However, it is also possible that the change in the probability of default from a change in the proportion of problem drywall decreases with the proportion of such drywall present. For example, if there are large lump-sum costs of remediation, then we can expect that a partial distribution of drywall over a greater number of homes will result in more foreclosures than a concentration of problem drywall in a few homes.

The foreclosures described above are assumed to have been caused by the problem drywall itself, i.e., a direct effect of the drywall on foreclosures. There is, however, the possibility of an

indirect effect such that even those homes that have non-problem drywall suffer a decline in value.

Indirect Consequences

Economic theory suggests two interrelated mechanisms by which the presence of problem drywall, even if it is not problematic, may impact the value of homes containing it: (i) via a cost-to-cure effect, covered above; and (ii) via an "intangible" stigma effect. In addition to the cost of remediation, problem drywall may also impact the value of homes having – or suspected of having – it by way of a stigma effect. Mundy (1992) notes that "an environmental stigma results from perceptions of uncertainty and risk" associated with contamination that arises from a fear of negative financial, health, and/or other consequences. The stigma effect of environmental contamination is often much more complicated to estimate, and is perhaps more enduring than the cost-to-cure effect (McCluskey and Rausser, 2003).

The logic of stigma in the context of problem drywall is straightforward: even if the material has been removed – but especially if it has not – prospective buyers may have concerns about continued financial, health, or other risks associated with the property. Importantly, this risk is presently demonstrable via no more than a casual reading of recent newspaper articles, which are known to systematically influence real estate markets (Clark et al., 1997; Clark and Allison, 1999). What is more, that same sense of stigma may extend to properties containing such drywall, but that have not exhibited any offensive odor or any other symptoms. This is important because even though most reported negative incidents are in the Southeast where heat and humidity may act as a catalyst,[28] the drywall has been used elsewhere. Even if it takes a combination of intense heat and humidity to trigger the problems of some drywall, there may be patterns of geographic transference due to the material's high degree of visibility in the news and other media. If true, prospective buyers in a distant part of the country may be turned off even if they face little or no risk. Note, however, that research also illustrates that

[28] Environmental Health and Engineering (2010) found that the concentration of hydrogen sulfides in indoor air of CPSC's complaint homes is positively and significantly correlated with the dew point, which is a function of temperature and relative humidity.

the degree, nature, and existence of stigma effects fluctuate through time and across geographic space (Carruthers and Clark, 2010).[29]

In sum, there is good reason to suspect that presence of Chinese drywall, whether problematic or not, may have an appreciable negative impact on the value of homes that contain it. If the drywall is problematic, there is a cost-to-cure effect, which corresponds to the cost – in terms of both money and inconvenience – of making the affected homeowner "whole" again. Beyond the cost-to-cure effect, there is a less tangible, yet still important stigma effect associated with the fact that homes that were once contaminated may continue to be perceived as such[30], and the stigma effect may spread as information about the risks associated with problem drywall spreads. At present, some uncertainty exists about what actually causes or triggers the problem, and this uncertainty may lead to losses in value in parts of the country where there is no known risk, i.e., hypothetically, a hot humid environment may trigger the problem, but homes located in cool, dry environments may be impacted by a transference of information or misinformation, as the case may be. If the stigma effect is substantial in the case of drywall imported from China, then the relevant baseline of homes affected would be the number of homes built with Chinese drywall (25,000 or 31,000) rather than the number of homes built with problem drywall (11,000 or 24,000). On the other hand, the stigma effect is likely to weaken over time as methods of identifying problem drywall are developed in order to reduce homebuyers' uncertainty.

Housing Market and Problem Drywall

There are three primary and well understood causes of the foreclosure crisis, and problem drywall is not among them: (i) a slowdown in housing appreciation followed by depreciation in

[29] To understand why this is the case, consider the role of information in the housing market. In order for markets to operate efficiently, both buyers and sellers must be well-informed of the costs and benefits associated with their transaction. Hite (1998) finds that buyers in the housing market typically are not well-informed about deleterious environmental factors, such as contamination. When they are, they bid prices down accordingly. And this is in agreement with a large pool of empirical evidence finding that various forms of environmental contamination have adverse effects on housing and other real estate markets (see Freeman 2003).

[30] McCluskey and Rausser (2010) provide evidence that the rapid recovery of property values after cleanup from an environmental contamination is a likely market outcome.

many areas of the country; (ii) weak economic conditions in many parts of the nation, and (iii) growth in the volume of risky loans (U.S. Department of Housing and Urban Development, January 2010). Despite the severity and intractability of the drywall problem for affected households, it is not considered by expert analysts to have played any substantive part in precipitating the foreclosure crisis. Although Florida has experienced the majority of drywall cases, economic trends in Florida are such that a foreclosure crisis there was even more likely than in the average state: (i) the share of high-cost loans in 2006 was 37.0 percent compared to a 27.2 percent national average; (ii) the annual decline in home prices in 2008 was 20.1 percent in Florida as compared to 3.9 percent nationally; and (iii) the unemployment rate was 6.2 percent in Florida as compared to 5.3 percent nationally (U.S. Department of Housing and Urban Development, January 2010). In sum, the drywall problem did not cause the foreclosure crisis, not even in Florida where the drywall problem is at its worst.

An idea of the relative scale of the foreclosure crisis can be gained by comparing a hypothetical number of foreclosures caused by problem drywall with the actual foreclosures completed. Suppose, in a, worst-case analysis, that all of the foreclosures caused by problem drywall were completed during 2007 and 2008.[31] If 50 percent of all homes that could have been built with problem drywall imported from China between 2004 and 2007, approximately 5,500 homes, went into foreclosure[32] that number would account for only 0.4 percent of all completed foreclosures nationally during 2007 and 2008. In short, even if a large proportion of homes containing problem drywall went into foreclosure, the number would still appear small against the national backdrop. The proportion of foreclosures caused by drywall in Florida is higher at 4.4 percent of foreclosure completions[33] during 2007 and 2008. If half of the upper estimate of

[31] Many homes will take some time to reach foreclosure. First, the homeowner has to realize the difficulty of problem drywall and then many will attempt remediation before default. The process of foreclosure itself can take months or as long as two years to complete (Getter,

[32] As explained, not all of the Chinese drywall is problematic, and some of it may never even be detected, so it is not reasonable to suspect that all homes containing it would go into foreclosure.

[33] The foreclosure completion statistic reflects the number of properties that have been foreclosed upon. It is sometimes referred to as "REO" or real estate owned. It is different from total foreclosure in that total foreclosure

homes with problem drywall were foreclosed upon, then these foreclosures would represent an equivalently higher fraction of the total inventory of foreclosures: 1 percent of the inventory of foreclosures nationally and 9.4 percent of foreclosure completions in Florida.[34]

Property Insurance Issues

Property insurance has not been an issue per se, but the lack of insurance as a remedy for the drywall problem has been. Whatever the exact origin of the sulfur emissions by some of the Chinese-manufactured drywall, the insurance industry has by-and-large treated it as a form of pollution, thereby compounding an already thorny problem. The so-called "pollution exclusion" clause in most property insurance policies exempts insurers from having to pay damages associated with environmental contamination. The pollution exclusion emerged in the wake of several large lawsuits seeking redress for industrial pollution in the 1970s. Today, it is common practice for comprehensive general liability insurance policies to eliminate coverage for nearly all types of pollution damage (Lamden, 2010). The property insurance industry followed the standard first set by the commercial insurance industry and added pollution exclusion clauses to home insurance policies.

Hydrogen sulfide and other sulfur compounds emitted from problem drywall are viewed as pollution by the insurance industry. Accordingly, insurers have consistently denied claims made by homeowners and homebuilders alike for damages associated with the problem drywall based on the pollution exclusion. Whether a homeowner is seeking compensation from their home insurance company or damages from a builder's insurance company, the pollution exclusion clause is a fundamental barrier to compensation because it is present in both home and commercial general liability policies (Mowbray, 2009; Dybdahl, 2009). The original purpose of the pollution exclusion is a matter of ongoing dispute but, until it is resolved, its role in compounding the problem presented by the drywall is clear: owners of homes containing

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statistics includes defaults and auctions which do not always end in foreclosure if the lender or borrower find a way to cure. Thus, the completion is a more restrictive definition of foreclosure.

[34] Annual data on foreclosure completions were forwarded to HUD staff by Realty Trac on July 22, 2011.

affected drywall and the builders who used it are left exposed and have no obvious avenue of recourse.

As a consequence, homeowners have been forced to pursue their insurers and the insurers of builders, drywall suppliers, and others (Mowbray, 2009). Relief to homeowners from insurance companies has not been forthcoming: most insurance companies have yet to pay any claims (Martin, 2010) and some have responded by filing lawsuits of their own against builders (Casale, May 2010). Beyond the pollution exclusion, another justification that insurers have used is the "latent defect" exclusion. The view of many insurers is that the role of home insurance is not to insure against problem material that the homeowner – or their agent – has installed. Consider the kind of perverse incentives that could arise to cut all manner of corners when renovating a home if negative outcomes were dispelled by insurance. In other words, residential property insurance is not viewed as a warranty against problem material – whether installed intentionally or not – but, instead, it is viewed as insurance against sudden accidental events, or "acts of god." Here again, there is disagreement over the interpretation: some attest that, like the use of the pollution exclusion, the use of the latent defect exclusion in the case of drywall that emits sulfur compounds is questionable. A 2000 Louisiana State Supreme Court Case found that the pollution exclusion should not be applied to homeowners who unintentionally find themselves in polluted homes. A past president of the Louisiana Association of Justice has stated that latent defect denials could be challenged at least on the basis of the indirect damage caused to wiring and fixtures (Mowbray, 2009).

In the face of these alternative interpretations of what insurers are liable for, parties on both sides of the dispute have turned to the courts. One broad wrinkle in this process is that the outcome of litigation over insurance liability depends in a fundamental way upon the local interpretation of the law that often varies by state, and even by jurisdiction within a given state (Casale, May 2010).

Finally, a number of other questions for homeowners besides the role of the pollution exclusion (and other exclusions) remain. A crucial question concerns the timing and interpretation of when the drywall incident occurs. For example, Louisiana has a two-year time limit for

homeowners to file claims, so that if the clock starts running when the drywall is installed rather when the problem is first noticed, homeowners who have had problem drywall in their homes in 2006 will automatically have their claims denied. Another issue concerns the effect of sulfur compound emissions by drywall on the broader integrity of homes containing it. As an example, it is not clear how insurers would respond to an electrical fire caused by wiring that was first corroded by problem drywall. Moreover, even if suits against builders' insurance companies are successful, damages may be quite constrained because many small builders carry only about $1 million worth of coverage (Mowbray, 2009). It goes without saying that litigation is unpleasant to all involved, but perhaps especially unpleasant to homeowners and homebuilders who may feel randomly injured by such product.

Recommendations

The problem drywall experience of the past 5 years has highlighted a number of issues that warrant new or continued attention from policy-makers and the construction industry. These issues point to potential actions that can be taken to ensure that another problem similar in form to this one never occurs.

- Recommendation 1: Consistent with the National Technology Transfer and Advancement Act and OMB Circular A-119, HUD should work with other government agencies and the industry to identify opportunities for national standards and testing protocols for construction materials that could be incorporated into the model building codes.
- Recommendation 3: Actively encourage Fannie Mae and Freddie Mac (the Government Sponsored Enterprises (GSEs)) to extend the period of loan forbearance under their policy to 12 months. While the Federal Housing Administration (FHA) and the GSEs have both pursued a policy of loan forbearance (U.S. Department of Housing and Urban Development, 2009; Fannie Mae, 2010), the GSE forbearance period is only six months as opposed to the FHA's twelve. The GSEs should be encouraged to match the FHA policy.

Summary of Findings

This report addresses questions surrounding drywall imported from China, some of which has proven to have problems that unfolded during the 2004 to 2007 timeframe and the set of insurance issues that have since materialized. The specific objectives were to: (i) explain why certain drywall – namely, that imported from China (primarily) in 2006 – can be problematic; (ii) locate the drywall problem within the context of the foreclosure crisis that emerged in the middle part of the past decade and evaluate the potential extent of its contribution to it; (iii) develop an estimate of the economic value of the problem; (iv) identify the salient property insurance issues and describe how these issues may have contributed to the broader problem; and (v) suggest how the federal government may help to ameliorate the problem.

Overall, the analysis reveals that the maximum number of foreclosures caused by the direct effects of problem drywall is 11,000 (or a non-primary estimate of 24,000 using publically available information), exactly corresponding to the estimated number of homes with problem drywall. Only a small amount of drywall was imported from China – enough to build an estimated 25,000 (and as many as 31,000) homes, and not all of those will have problems – but the impact on individual homeowners may be very large. The drywall's contribution to the foreclosure crisis is small with respect to the size of the still-ongoing dislocation, but homeowners faced with the problem are severely impacted and may have an increased incentive to default on their mortgages. The study places primary emphasis on the lower end of the distribution (11,000 maximum foreclosures directly caused by problem drywall) because this estimate incorporates non-public information obtained from the CPSC. The range of estimates represents 0.4 to 1.0 percent of all foreclosures completed in 2007 and 2008., and smaller percentages when foreclosures over a broader period are considered.

However, it is reasonable to expect that only a fraction of the total number of homes with problem drywall will result in a completed foreclosure. If one-half of the homes assumed to be built with problem drywall went into foreclosure, then the foreclosures caused by problem drywall would amount to approximately 5,500 - 12,000 or 0.5 - 1.1 percent of the national inventory of foreclosures at the end of the first quarter of 2008.

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Figure 1. Percentage of Prefabricated Drywall imported by Country

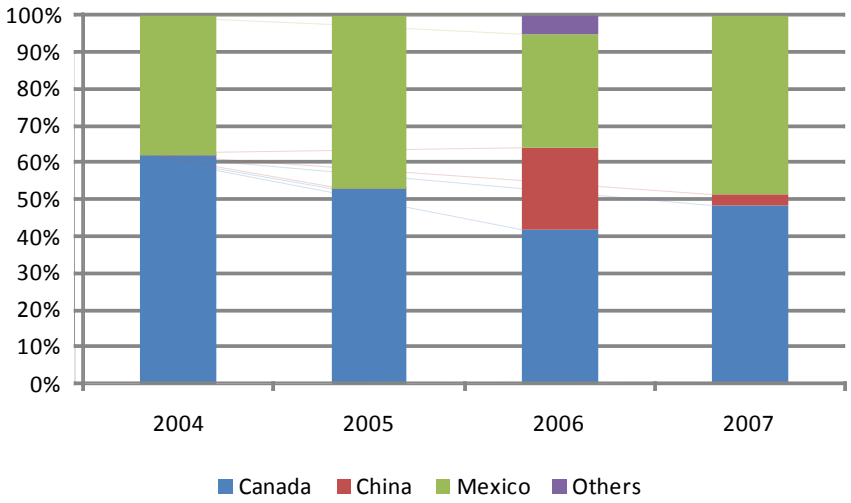

Figure 2. Reported Incidents of Problem Chinese Drywall and Ports of Entry

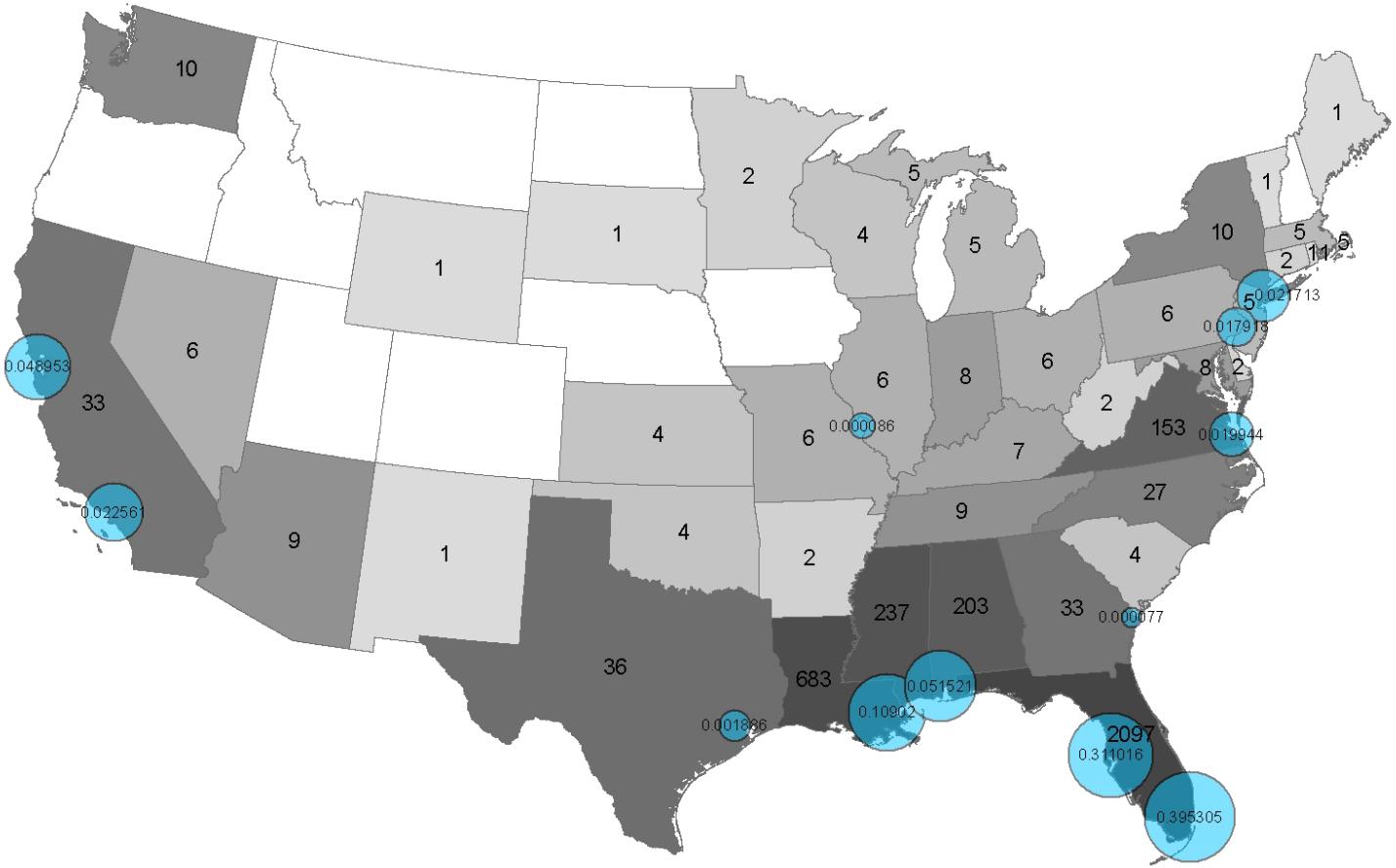

Table 1. Metric Tons of Imported Drywall, 2004 - 2007

	2004		2005		2006		2007	
	Metric Tons	% of Total	Metric Tons	% of Total	Metric Tons	% of Total	Metric Tons	% of Total
Canada	382,697	62.0	389,628	52.7	416,345	41.9	211,989	48.4
China	10	0.00	369	0.05	218,100	22.0	12,371	2.8
Mexico	234,085	38.0	348,014	47.1	306,508	30.8	213,882	48.8
Others	83	0.01	1,136	0.2	52,876	5.3	244	0.06
Total	616,875		739,147		993,829		438,486	

Source: United States Trade Commission, dataweb.usitc.gov, (HTS Code 68091100)

Table 2. Number and Percentage of Reports by State – as of October 15, 2010

	Number of Reports	Percent of All Reports
Florida	2097	57.45%
Louisiana	683	18.71%
Mississippi	237	6.49%
Alabama	203	5.56%
Virginia	153	4.19%
Texas	36	0.99%
California	33	0.90%
Georgia	33	0.90%
North Carolina	27	0.74%
New York	10	0.27%
Washington	10	0.27%
Arizona	9	0.25%
Tennessee	9	0.25%
Indiana	8	0.22%
Maryland	8	0.22%
Kentucky	7	0.19%
Illinois	6	0.16%
Missouri	6	0.16%
Nevada	6	0.16%
Ohio	6	0.16%
Pennsylvania	6	0.16%
District of Columbia	5	0.14%
Massachusetts	5	0.14%
Michigan	5	0.14%
New Jersey	5	0.14%
Kansas	4	0.11%
Oklahoma	4	0.11%
South Carolina	4	0.11%
Wisconsin	4	0.11%
Arkansas	2	0.05%
Connecticut	2	0.05%
Delaware	2	0.05%
Montana	2	0.05%
West Virginia	2	0.05%
Maine	1	0.03%
New Mexico	1	0.03%
Rhode Island	1	0.03%
South Dakota	1	0.03%
Vermont	1	0.03%
Wyoming	1	0.03%
American Samoa	1	0.03%
Puerto Rico	1	0.03%
Unknown	3	0.08%
Total	3650	100.00%

Source: US Consumer Product Safety Commission

Table 3. Imports of Drywall from China In Metric Tons, Square Feet, Estimated Homes Built, and Share of Total Port of Entry, 2004 - 2007

Port of Entry	Metric Tons	Square Feet	Share of Subtotal	Upper Estimate of Number of Homes Built	Lower Estimate of Number of Homes Built
Miami, FL	87,607	113,579,899	39.5%	11,777	9,657
Tampa, FL	68,927	89,361,828	31.1%	9,266	7,598
New Orleans, LA	24,161	31,324,026	10.9%	3,248	2,663
Mobile, AL	11,418	14,803,101	5.2%	1,535	1,259
San Francisco, CA	10,849	14,065,409	4.9%	1,458	1,196
Los Angeles, CA	5,000	6,482,353	2.3%	672	551
New York, NY	4,812	6,238,616	2.2%	647	530
Norfolk, VA	4,420	5,730,400	2.0%	594	487
Philadelphia, PA	3,971	5,148,285	1.8%	534	438
Houston-Galveston, TX	418	541,925	0.19%	56	46
St. Louis, MO	19	24,633	0.01%	3	2
Savannah, GA	17	22,040	0.01%	2	2
Honolulu, HI	3	3,889	0.0%	0	0
SUBTOTAL	221,622	287,326,405	100%	29,792	24,430
All Other Ports	9,229	11,965,127		1,241	1,017
All Ports	230,851	299,291,532		31,033	25,447

Source: United States Trade Commission, dataweb.usitc.gov, (HTSCode68091100)

Table 4. Relationship between living area and drywall used in home construction.

Year	Living area (square feet)	Drywall used (square feet)	Drywall/living area
2006	2,420	8,985	3.713
2009	2,235	8,375	3.747
Average	2,327.5	8,680	3.729

Source: National Association of Home Builders (2007, 2010)

Table 5. Number of Foreclosures*						
	Homes Built with Chinese Drywall:		Resulting Foreclosures Given a Foreclosure Rate of:			
	Primary (Lower) Estimate		**Primary (Lower) Estimate**			
Area	**Total**	**Problem Dry-Wall**	**10%**	**25%**	**50%**	**100%**
Nationwide	25,000	11,000	1,100	2,800	5,500	11,000
Florida	17,000	7,400	740	1,900	3,700	7,400
	Upper Estimate		**Upper Estimate**			
	Total	**Problem Dry-Wall**	**10%**	**25%**	**50%**	**100%**
Nationwide	31,000	24,000	2,400	6,100	12,000	24,000
Florida	21,000	16,000	1,600	4,100	8,200	16,000

*Any minor discrepancies in this table between homes built and resulting foreclosures are due to the rounding of all figures to two significant digits.

Table 6. Summary of Calculation of Number of Homes with Problem Drywall *Imported from China (2004 – 2007)*		
Parameter	**Primary (Lower) Estimate**	**Upper Estimate**
(1) Metric tons of drywall	230,851	230,851
(2) Pounds of drywall (1) X 2204	508,796,000	508,796,000
(3) Pounds of ½" drywall per square foot	1.7	1.7
(4) Square feet of drywall (2)/(3)	299,000,000	299,000,000
(5) Proportion of drywall unused	18%	0%
(6) Square feet of drywall used in construction (1-(5)) X (4)	245,000,000	299,000,000
(7) Square feet of drywall per square foot of floor area in 2006 (Table 4)	3.713	3.713
(8) Floor area (square feet)	2,286	2,286
(9) Square feet of drywall per home (7) X (8)	8,488	8,488
(10) Potential homes built from drywall (6)/(9)	28,900	35,200
(11) Percentage of waste	12%	12%
(12) Homes built net of waste (1 – (11)) X (10)	25,400	31,000
(13) Incidence of problem drywall	43%	78%
(14) Stock of problem homes (13) X (12)	11,000	24,000