



The Tool and Die Industry: Contribution to U.S. Manufacturing and Federal Policy Considerations

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Summary

Tools, dies, and molds are fundamental to durable-goods manufacturing. Tools are used to cut and form metal and other materials. Dies are metal forms used to shape metal in stamping and forging operations. Molds, also of metal, are used to shape plastics, ceramics, and composite materials. Tool and die companies, typically small businesses staffed by skilled craft workers, make it possible for their customers to manufacture innovative products, from auto parts to household appliances to fighter planes.

Since 1998, over one-third of U.S. tool, die, and mold establishments have gone out of business, closing at twice the rate of manufacturers in general. Employment has fallen by nearly half. Some of that decline is due to the introduction of new technology that has reduced the need for highly trained toolmakers and die makers. About half of toolmakers' work is for the motor vehicle industry, and the steep downturn in U.S. vehicle production was a significant factor in their decline. In addition, the industry has lost ground because of the shift of major U.S. customers abroad, especially to China, where U.S. manufacturers generally use local toolmakers. Compounding that trend is the expansion of foreign auto manufacturers in the United States, some of which reportedly retain ties to tool, die, and mold makers in their home countries.

The health of tool and die makers is likely to be of concern to Congress, because they are a small but critical part of durable goods manufacturing. Congress has long shown special concern for the industry because of the highly skilled nature of the jobs it provides and because of its importance to manufacturing. The issues facing the tool and die sector are a microcosm of the challenges facing policymakers as they seek to promote high-value manufacturing in the United States.

In addition to global competitiveness issues, the tool, die, and mold industry may face a skills shortage. The average age of a toolmaker is 52, and many experienced toolmakers are expected to retire in the next few years. Managers of tool and die companies say there is a lack of workers with sufficient training in mathematics and in technology applications to replace workers as they retire.

The industry's prospects are closely tied to the outlook for durable-goods manufacturing in general. The revival of auto manufacturing and the domestic expansion of other durables manufacturers in the United States may offer new opportunities for firms that have survived the tool and die industry's long slump. On the other hand, contraction of defense procurement spending could hurt tool and die makers, and the increase of Chinese auto parts imports may pose new challenges.

Federal policy options include support for worker training and technology programs, extension of tax incentives for purchasing new equipment and greater scrutiny of alleged subsidies of foreign tool and die makers.

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Introduction

Tool and die manufacturing has long been considered a key industrial sector. Congress has been concerned about its health for at least two centuries, since Eli Whitney, an early American inventor, used the antecedents of today's tools and dies to manufacture interchangeable firearms parts for use by the U.S. government in the War of 1812.¹ During World War II and part of the Vietnam War, toolmakers could be exempted from the military draft because they were deemed "critical occupations".² In 1970, a congressional committee found that "the tool, die and precision machining industry, as a supplier of basic production equipment, has been and continues to be a very important factor in meeting the commercial needs of the country."³ And at the beginning of twenty-first century, the Chairman of the House Ways and Means Committee requested the U.S. International Trade Commission to study the industry's health in light of globalization trends.⁴

The tool and die industry is of particular concern at present due to the general congressional interest in spurring domestic manufacturing. Without the manufacturers who design and make the tools, dies, jigs, and molds used to make other products, a revival of the domestic auto and appliance industries would be difficult to envision.⁵ The auto industry alone accounts for half of all tooling consumption,⁶ and much defense-related manufacturing also requires tools and dies.

What Are Tools and Dies?

A *tool* is a precision device for cutting or shaping metals and other materials.

A *die* is a form used to shape metal in forging and stamping operations. Dies also include metal *molds* used in making plastics, ceramics, and composite materials.

A *jig* is used to hold metal while it is being drilled, bored or stamped.

While the tool and die industry has always been subject to U.S. economic swings and foreign competition, the rise of China's manufacturing sector over the past decade had brought it under particular stress. In 2006, one tool and die maker testified before a commission on U.S.-China relations that:

companies are facing fierce foreign competition as the OEMs [original equipment manufacturers] are purchasing parts, tools and dies and molds in China for as much as 35% less....The Chinese build tools that require more maintenance as labor is cheap in their

¹ Encyclopædia Britannica, *Tool and Die Making*, Academic Edition, <http://www.britannica.com/EBchecked/topic/599441/tool-and-die-making>.

² U.S. Congress, House Armed Services, *Extension of the Universal Military Service and Training Act*, 90th Congress, 1st Session, May 2, 1967, pp. 2073 and 2551.

³ U.S. Congress, House Select Committee on Small Business, *Problems Facing the Tool and Die Industry*, committee print, 91st Cong., 2nd sess., February 9, 1970, H.Report 91-832, p. 1.

⁴ Letter from Bill Thomas, Chairman, Committee on Ways and Means, to Stephen Koplan, Chairman, U.S. International Trade Commission, December 20, 2001.

⁵ According to one tool builder, the Chinese recognize the significance of tool and die making by referring to the industry as the "mother of manufacturing." CRS interview on February 6, 2012 with Michael Korneli, president, Bestech Tool Corp., West Bend, Wisconsin, <http://www.bestechtool.com>.

⁶ U.S. International Trade Commission (USITC), *Tools, Dies, and Industrial Molds: Competitive Conditions in the United States and Selected Foreign Markets*, USITC Publication 3556, October 2002, p. xiv.

country and in many instances do not use robust steels. They supply a cheaper tool that can be built for less, yet customers put their prices against ours.⁷

Foreign competition, application of new technologies, and two recessions caused a loss of more than a third of all tool and die establishments since 1998 and a reduction of the workforce by nearly half. There are signs that the tide may be turning: U.S. durable-goods manufacturing appears to be reviving, which could benefit U.S. tool and die makers. But due to technological change, the industry is likely to operate differently than in the past, and to require a workforce with a different set of skills.

This report reviews the role of tool and die makers in durable goods manufacturing and summarizes federal policy issues which may affect its future.

An Industry of Small Businesses

The tool and die industry represents a tiny portion of U.S. manufacturing, with total sales of \$11.7 billion in 2010. Nonetheless, it has an instrumental role in manufacturing. A 1975 analysis captured the nature of the industry:

While mass production is made possible by tooling, the principal tools themselves cannot be mass produced. Tool making, and especially mold and diemaking, is one of the few activities connected with modern large-scale industry in which there has not been a general substitution of machinery for basic skills. These tools are custom-made, one-at-a-time by skilled artisans who patiently and precisely machine, finish, and construct the complicated devices. Only one die, or set of dies, is needed for the manufacture of many thousands, and sometimes millions, of automobile fenders or hoods of a given design.... The one-of-a-kind characteristic of the tooling industry accounts for enormous differences in management and capitalization strategies, and the skills, machinery, and technology amenable to tooling-making and mass production.⁸

The tool and die industry is primarily made up of small businesses using skilled employees with many years of experience. Nine out of ten tool and die industry firms employ fewer than 50 workers.⁹ These firms are generally privately owned and often family operated.

As shown in **Table 1**, the number of U.S. tool and die establishments dropped by 36% between 1998 and 2010, more than twice the rate of decline in the total number of manufacturing establishments. Employment in tool and die has dropped more steeply as well.

⁷ U.S.-China Economic and Security Review Commission, *China's Impact on the U.S. Auto and Auto Parts Industries*, Panel on "Perspectives of Tool and Die Manufacturers", 109th Cong., 2nd sess., July 17, 2006, Statement of Laurie Schmalz Moncrieff, President, Schmalz Tool and Die, Inc., Flint, Michigan, p. 145.

⁸ Harold E. Arnett and Donald N. Smith, *The Tool and Die Industry: Problems and Prospects* (Ann Arbor, Michigan: Graduate School of Business Administration, the University of Michigan, 1975), p. 6.

⁹ USITC, *Tools, Dies, and Industrial Molds*, p. xiii.

Table I. U.S. Manufacturing and Tooling Trends

Category	1998	2005	2008	2010	Percent Change 1998-2010
Employment					
Manufacturing	17,616,672	14,190,394	13,382,697	11,487,496	-35%
Tooling	162,032	119,308	107,187	89,661	-45%
Annual payroll					
Manufacturing	\$679 billion	\$699 billion	\$728 billion	\$661 billion	-3%
Tooling	\$6.9 billion	\$5.7 billion	\$5.4 billion	\$4.7 billion	-32%
Number of establishments					
Manufacturing	412,453	365,351	359,844	342,844	-17%
Tooling	9,057	7,192	6,393	5,789	-36%

Source: Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages.

Notes: Tooling refers to NAICS Codes 333511 (Molds) and 333514 (Dies, Jigs & Fixtures). The North American Industrial Classification System (NAICS) is the standard used by federal statistical agencies in classifying business establishments.

Tool and die making contracted more than overall manufacturing because of the nature of that business. Tool and die makers rely on a continuous flow of new orders for tools, dies and molds to make new products. As long as their larger manufacturing customers are updating vehicles, appliances, or other products, there is a steady need for tools and dies. But when their customers retrench, tool and die production is affected disproportionately. As one tool and die expert noted, contrasting tooling with other kinds of manufacturing, “if...the ‘build’ volume of an existing car model dropped by 20%, the parts manufacturer would experience a 20% drop in business. But when a project is cancelled or delayed, the tool and die makers would see their business drop precipitously – maybe dropping to zero, if things got really bad.”¹⁰

Although tool and die firms are small in number and total employment, they play a central role in manufacturing innovation: any durable-goods manufacturer seeking to introduce a new product is likely to require customized tools, dies, and molds to make metal, plastic, and ceramic components. While most tool and die production is used to make consumer durable goods, the industry also plays an important role in manufacturing of such military equipment as jet aircraft, missiles, tanks, and electronics.

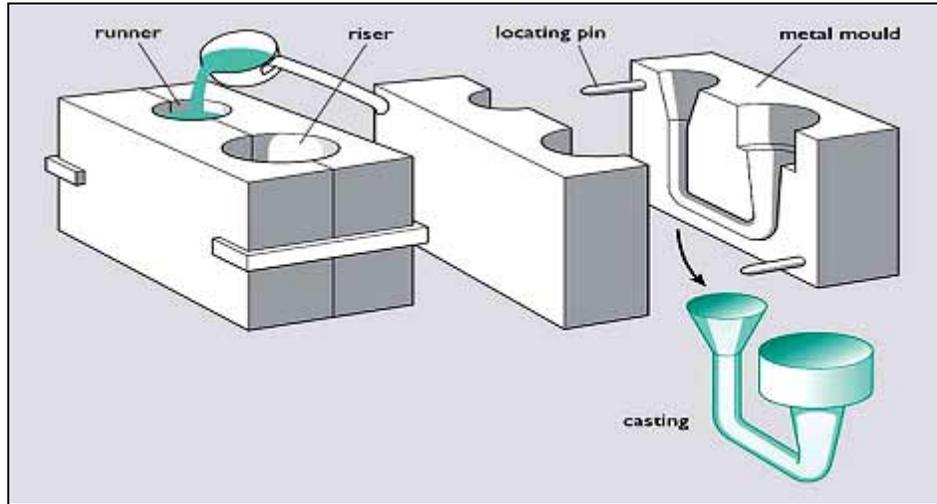
Figure 1 shows a simplified example of a part being made in a die. The die maker creates the two parts of the mold. Molten metal, propelled in this example by gravity, is poured into the shape and when it has hardened, the two sections are pulled apart to release the newly formed part.¹¹ This

¹⁰ CRS interview on February 15, 2012 with William Gaskin, president, Precision Metalforming Association (PMA). Conversely, there can be sharp jumps in tool and die demand once durable-goods orders start to rise in an economic recovery.

¹¹ Gravity die casts are only one type of die casting. Others include centrifugal casting, sand casting, and pressure die (continued...)

process is performed over and over again. Sometimes a new mold is used each time; in other cases, the mold is reused many times. Without the mold made by the die maker, it would not be possible to mass produce the parts.

Figure 1.A Cast Iron Mold
How Gravity Die Casting Works



Source: Industrial Metal Casting, <http://www.industrialmetalcasting.com/gravity-die-casting.html>.

Where are Tool and Die Makers Located?

Nearly every state has some tool and die making capacity, but the upper Midwest generally has the largest numbers of companies and employees because tool and die makers are closely tied to durable goods industries—such as motor vehicle and appliances—which have plants in that region. The top ten states by number of tool, die and mold makers are listed in **Table 2**. The two outliers are California and New York: California is the largest manufacturing state in the United States, with a large aerospace sector, and New York has a number of auto parts suppliers.

Table 2. Top States in Tool, Die, and Mold Employment
States ranked by 2010 employment

State	2001	2010	Percent Change
Michigan	30,208	18,871	-27%
Ohio	17,056	11,075	-28
Illinois	12,822	6,815	-31
Pennsylvania	11,811	6,476	-30
Wisconsin	7,309	5,359	-13

(...continued)
casting.

State	2001	2010	Percent Change
Indiana	8,571	5,228	-31
California	7,253	4,885	-23
Missouri	4,371	3,133	-11
New York	5,171	2,783	-30
Minnesota	3,933	2,749	-13

Source: Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages, 2001-2010, <http://www.bls.gov/cew/>.

Note: Employment shows those working in tools, dies and jigs (NAICS 333514) and industrial molds (NAICS 333511). The North American Industrial Classification System (NAICS) is the standard used by federal statistical agencies in classifying business establishments.

Factors Behind Tool and Die Demand

During the recent recession, U.S. durable goods orders fell by more than 21%, affecting all the major civilian customers of tool and die makers.¹² The current recovery in durable goods—output rose 7.9% between the final quarter of 2010 and the fourth quarter of 2011—is likely to bolster demand for tools and dies.¹³

Data on the extent of tool and die work in durable goods markets are not available, but estimates have been made for stampings (which approximate the die industry) and industrial molds. For stampings, the largest end users are: motor vehicle industry (50% of all stampings), appliances (5%), other motors/agricultural equipment (5%), construction industry(4%), and cookware (4%). For industrial molds, 41% of production is sold to the motor vehicle industry, 16% to electronics manufacturers, and 14% to appliance makers.¹⁴

The motor vehicle industry is thus the major end user of tools and dies. Like all auto suppliers, tool and die makers have been adversely affected by the downturn in the motor vehicle market since 2007. U.S. production of cars and light trucks fell by 31% between 2006 and 2010, one of the steepest declines in decades. This had an immediate impact on suppliers such as tool and die makers. When motor vehicle manufacturers cut back on design changes and reduce new model introductions, they need far fewer tools, dies, and molds. Since the trough of the recession in 2009, the domestic motor vehicle industry has recovered, with US-made car and light truck production increasing by over 50% from 2009 to 2011.¹⁵

¹² U.S. Census Bureau, “Manufacturers’ New Orders: Durable Goods,” as reported by the St. Louis Federal Reserve Bank, <http://research.stlouisfed.org/fred2/series/DGORDER/downloaddata?cid=32431>.

¹³ Output growth for durables manufacturing is taken from Federal Reserve Board, “G.17 – Industrial Production and Capacity Utilization,” February 15, 2012.

¹⁴ USITC, *Tools, Dies, and Industrial Molds*, Chapter 3, pp. 21-22.

¹⁵ U.S. car and light production rose from 5.8 million units in 2009 to 8.7 million units in 2011. Because of the ongoing problems in the housing market, where many appliances are sold, the appliance industry’s sales have been flat for the past three years. Sources: “North American Car and Truck Production,” *Automotive News*, and “Annual Shipment Trends,” Association of Home Appliance Manufacturers.

In general, U.S. manufacturers have moved away from making long runs of standardized products and toward production of more complex and customized products. This is relevant to the tool and die industry because the process of bringing forth new products hinges on the ability of tool and die makers to translate a blueprint into an accurate mold or die that will, in turn, produce the product innovation. Sales of tooling often depend on the introduction of new products which require new stampings, molded plastic parts, and die castings.

Tools and dies can be critical in the non-durables sector as well. In one publicized case, a tooling company in Redmond, Washington helped Microsoft design the molds used for a soap bar-shaped computer mouse; the mouse had eight components, requiring multiple molds so that any one of the components could be switched out. The same company was approached by a molder who made plastic disks for a blood centrifuge. The toolmaker needed to come up with a mold that would produce disks containing tiny channels with precise dimensions, although the changes were too small to be seen with the naked eye.¹⁶

To meet such demands, tool and die makers are often forced to invent new technologies. One company in Houston, TX specializes in a type of tooling known as electrical discharge machining (EDM). According to a handbook developed by the owner, “in the early ‘70s, a typical wire EDM machine cut two square inches an hour; today they are rated to cut 20 times faster and produce submicron finishes.” The resulting products are used in such fields as medical and dental instruments and space-industry applications.¹⁷

Even as the tool and die industry is aided by a recovery in commercial manufacturing, it may be adversely affected by potential reductions in defense industries: if budget constraints lead to fewer new planes, tanks, and vehicles, the makers of such products will need fewer tools and dies. If, however, the armed services are forced to keep older equipment (such as the B-52 bomber) in operation, the tooling industry could benefit. Tool and die makers have a potential role in producing parts for military equipment that may remain in service long after the original manufacturers have stopped supplying parts. Repairing such legacy systems may require tool and die makers to build new tools and dies to recreate the necessary parts.¹⁸

Global Competition

U.S. manufacturing has been buffeted by rising manufacturing capacity and employment abroad. The shift in the tool, die and mold industry has been especially pronounced over the past decade. The National Tooling and Machining Association (NTMA) estimated that 30% of U.S. toolmakers closed just between 2000 and 2003. In 2003, a *Wall Street Journal* report noted that

U.S. toolmakers withstood growing competition from lower-cost foreign producers for years. But China’s sudden emergence as a manufacturing powerhouse and an unbeatable pricing opponent has them reeling.¹⁹

¹⁶ Appel, “With Foreign Rivals Making the Cut, Toolmakers Dwindle.”

¹⁷ Carl Sommer and Steve Sommer, M.E., “Understanding Electric Discharging Machinery,” in *Complete EDM Handbook* (Houston, 2005), p. 22. Carl Sommer founded Reliable EDM, a tooling company. This handbook is used as a textbook in some colleges and technical schools.

¹⁸ “Upgrades to Keep B-52s Flying Through 2040,” *Air Force Times*, October 4, 2011.

¹⁹ Appel, “With Foreign Rivals Making the Cut, Toolmakers Dwindle.”

Foreign competition is not new to this industry, as tools, dies, and molds have long been traded globally among major industrial countries. In the past, because of the close relationship between the two economies and unrestricted cross-border trade in motor vehicles, Canada has been a major source of tools, dies, and molds as well as an export market for U.S. manufacturers. Since the end of the 1990s, imports have increased more rapidly than exports. The most significant change has been the 268% rise in the importation of industrial molds, as shown in **Table 3**.

Table 3. Trade in Tools, Dies, and Industrial Molds

Millions of U.S. dollars

Product	Exports	Imports
Molds		
1997	\$648	\$1,291
2010	717	4,745
Tools, dies and jigs		
1997	442	696
2010	488	851
Total		
1997	1,090	1,987
2010	1,205	5,596

Source: CRS analysis based on statistics from the U.S. Department of Commerce and U.S. International Trade Commission (USITC).

The rising industrial mold imports originate largely in Japan, the Netherlands, China, Germany and South Korea. When Canadian molds are included, these six countries account for nearly 90% of all mold imports, with Japan alone accounting for nearly half.²⁰ Exports of molds have only increased modestly since 1997 but the trade pattern has shifted as well, with Mexico replacing Canada as the largest market for U.S. molds.²¹

Tool and die imports have risen by about 22% since 1997, with Japan and Canada remaining the top two origins. Top export destinations have remained Canada and Mexico.²²

Import and export data do not give a complete picture of global competition in the tool, die, and mold industries. Many firms in the sector have been affected by their U.S. customers moving manufacturing operations abroad and, in so doing, also moving their sourcing of tools, dies, and molds abroad. In addition, some foreign tool, die, and mold makers have set up shop in the United States.

²⁰ By contrast, Canada accounted for half of all mold imports in 1997. Statistics for 2010 from the U.S. Department of Commerce and U.S. International Trade Commission; 1997 data is USITC, *Tools, Dies and Industrial Molds* Chapter 3, p. 40.

²¹ Ibid. Data for 1997, p. 44.

²² Ibid, pp. 41 and 45.

The USITC report cited earlier pointed out that the growing share of U.S. motor vehicle production owned by foreign companies was causing

particular difficulties for the U.S. tooling firms serving the automotive industry since many of these firms have largely concentrated their efforts on marketing their tooling to the Big Three automotive OEMs [original equipment manufacturers: General Motors, Ford and Chrysler], often to the exclusion of foreign transplants.... At the same time, foreign automobile transplants in the United States have tended to continue tooling supplier relationships with toolmakers located in their home countries, some of which have established U.S. production operations to improve services.... It is often difficult for U.S. toolmakers to penetrate this market segment due to a reluctance by the foreign-based consumers to disrupt existing supplier relationships.²³

A 2011 report issued by Case Western Reserve University found that the erosion of auto industry tool and die makers accelerated as the U.S. economy weakened in the economic crisis of 2007 and afterwards. After surveying small- and medium-sized auto supplier firms, the authors concluded that these

firms have been outsourcing high-skill jobs, such as tool and die making, to lower-wage countries like China, reducing demand for these skilled trades within the U.S. Specifically, our survey indicates that 56.9 percent of tool and die plants have off-shored some work as a response to the crisis or beforehand, whereas 41.6 percent of non-tool and die plants respondents have done so. Tool and die plants have off-shored to high wage countries (41.2%) such as western Europe and Japan, to low-wage countries (41.2%) and to both high and low wage countries (25.5%).²⁴

Following the recent recession, two divergent global manufacturing trends are affecting the U.S. tool and die industry. The first is China's growing presence in the manufacture and worldwide shipment of auto parts. The auto industry has been designated a "pillar industry" by the Chinese government and it has major plans to expand auto and auto parts production.²⁵ Since 2008, Chinese auto parts exports to the United States have climbed by 43% to roughly \$10 billion, according to the USITC.²⁶ Several recent reports argue that auto parts production and exports are highly subsidized by the Chinese government.²⁷ Auto parts manufactured abroad which displace U.S.-made auto parts would likely reduce the demand facing domestic tool and die makers. Some tool and die executives believe that Chinese tools and dies will continue to have an advantage for high volume, less sophisticated parts manufacturing. They believe that will leave a continued market for U.S. tool and die makers producing high quality and precision tools, such as those that

²³ Ibid, pp. 37-38.

²⁴ Susan Helper, et al., *The U.S. Auto Supply Chain at a Crossroads: Implications of an Industry in Transformation*, Case Western Reserve University, August 1, 2011, p. 25, <http://www.drivingworkforcechange.org/reports/supplychain.pdf>. This report was funded by a grant from the U.S. Department of Labor's Employment and Training Administration, as part of the American Recovery and Reinvestment Act (ARRA). The authors are researchers in Michigan, Ohio and Indiana; they used both survey and other available data in their analysis.

²⁵ U.S. Congress, Joint Economic Committee, *China's Economic Future: Challenges to U.S. Policy*, edited by John P. Hardt and Robert Mottice, 104th Cong., 2nd sess., p. 296.

²⁶ "Chinese Auto-Parts Influx Worries Lawmakers," *Politico*, January 31, 2012.

²⁷ One report is by Robert Scott and Hilary Wething, *Jobs in the U.S. Auto-Parts Industry Are at Risk Due to Subsidized and Unfairly Traded Chinese Auto Parts*, Economic Policy Institute, January 31, 2012, https://docs.google.com/viewer?url=http://www.epi.org/files/2012/bp336.pdf&hl=en_US&chrome=true.

shape the intricate stampings for the interior metering components of automobile shocks and struts.²⁸

The other factor, which runs counter to the rise of Chinese imports, is the expansion of manufacturing capacity in the United States, possibly opening new opportunities for domestic tool and die builders. This shift in some kinds of production back to the United States is being driven by several factors. The increase in the value of the Chinese currency (the renminbi), which has appreciated more than 28% since China first permitted a controlled appreciation in 2005,²⁹ is making goods produced in China more expensive here, as is a Chinese government-backed effort to raise wages in many Chinese industrial regions. In addition, increasing logistics costs due primarily to the rise price of petroleum used to ship products from China to the United States is also a cost factor that may favor more domestic production. Many manufacturers located within the United States may prefer U.S.-made tools and dies to imports, as domestic producers are often able to deliver their tools and dies more quickly and can more easily provide support at the customer's premises. For example, a Wisconsin manufacturer of injection-molded plastic parts began sourcing tools in China in 2004, but now says that it buys 90% of its tools domestically because of shorter delivery times from U.S. companies and rising prices for Chinese tools and dies.³⁰

How tool and die makers will fare with these new supply chain developments is not clear. As if anticipating some return of U.S. manufacturing, the Case Western Reserve report noted that off-shoring is not necessarily permanent. The authors observed that tool and die jobs are "sufficiently complex, that off-shoring can be more difficult, time-consuming and costly than firms initially expect. Thus, even as quality increases at off-shore locations, some high-skill work remains on-shore and some initially outsourced work eventually returns to the United States."³¹ The earlier USITC study found a similar preference for manufacturers to source higher-value, lower-volume production domestically, where quality and finish are a major consideration.³² Should such supply chain shifts take place in durable goods industries, there could be an increased demand for the tool and die work that underpins such production.

There are alternative views, however. A recent Brookings Institution report contends that even if exchange rates are set by market forces and labor cost advantages abroad diminish, "it is very hard to revive an industry after its sales and employment have dramatically shrunk. Once the dense network of suppliers disappears, the fall in the dollar required to justify reinvestment is much greater than that necessary to expand existing operations....The frayed production networks in such industries as tooling and electronics should be cause for great concern."³³

²⁸ CRS interview on February 7, 2012 with Ron Overton, president, Overton Industries, with plants in Mooresville and Franklin, Ind., <http://www.overtonind.com>.

²⁹ For an analysis of the Chinese currency issues, see CRS Report RS21625, *China's Currency Policy: An Analysis of the Economic Issues*, by Wayne M. Morrison and Marc Labonte.

³⁰ CRS interview on November 21, 2011 with Tom Duffey, founder of Plastic Components, Germantown, Wisconsin, <http://www.plasticcomponents.com>.

³¹ Susan Helper, et al., *The U.S. Auto Supply Chain at a Crossroads*, p. 25, footnote 34.

³² USITC, *Tools, Dies, and Industrial Molds*, Chapter 3, p.38.

³³ Susan Helper, Timothy Krueger, and Howard Wial, *Why Does Manufacturing Matter? Which Manufacturing Matters?*, Brookings Institution, February 2012, p. 30.

It is possible that global production patterns may also shift work from China to other, lower-cost locations such as India, Vietnam, or Indonesia, or to China's lower-cost interior cities. Some economists and business analysts believe this is more likely than significant new manufacturing production coming to the United States.³⁴ Should these locations be new sites for manufacturing, the U.S. tool and die industry would most likely not see a rise in production and employment.

The Tool and Die Labor Force

Tool and die makers are machinists who understand how to use complex machines such as lathes, laser cutting machines, and milling machines. They must be familiar with handtools, heat-treating and plating. Because their work requires that parts fit together well in final assembly, they must know how to use precision measuring devices that measure precision to one ten-thousandth of an inch. In addition, they must be proficient in math—especially geometry, trigonometry and statistics—and blueprint reading, and have a good working knowledge of physics. As the Department of Labor *Occupational Outlook Handbook* describes the work,

once a tool or die is designed, tool and die makers, working from blueprints, plan the sequence of operations necessary to manufacture the tool or die. They measure and mark the pieces of metal that will be cut to form parts of the final product. At this point, tool and die makers cut, drill or bore the part as required, checking to ensure that the final product meets specifications. Finally, these workers assemble the parts and perform finishing jobs, such as filling, grinding and polishing surfaces.³⁵

Tool and die workers are responsible not only for designing the parts-making machines, but also for quality checks on the parts being produced by their tools and dies. Among the tools they use to gauge accuracy are measuring machines which employ sensors and software to compare the final products with the blueprints. Before a tool or die is turned over to the customer, workers may have to file, grind, and otherwise adjust it to ensure that the product being produced exactly meets specifications. While tool and die makers do most of their work in their own manufacturing production facilities, they may visit customers' plants to observe operations and suggest changes in methods and processes.

Technology is changing the tool and die makers' work. One tool and die maker estimated that technology and software applications have raised product quality and made tool and die makers as much as 20% more efficient.³⁶ Many workers now use computer-aided design (CAD) to design parts and blueprints for machines. Computer-aided manufacturing (CAM) programs take the CAD designs and convert them into sequenced instructions for cutting tools. Finally, computer numerically-controlled (CNC) machines follow the instructions embedded in the software to produce the part. While machinists may operate the CNC machines, tool and die makers, who are trained in writing CNC programs, may also be CNC operators.

³⁴ Josh Timberlake, Phil Schneider, and Shirley Dong Terry, *China: Still Manufacturing's Shining Star?*, Deloitte, January 18, 2011, http://www.deloitte.com/view/en_US/us/Insights/Browse-by-Content-Type/deloitte-review/de0ee6545eea2210VgnVCM200000bb42f00aRCRD.htm.

³⁵ Bureau of Labor Statistics, *Occupational Outlook Handbook, 2010-2011 Edition*, "Tool and Die Makers," <http://www.bls.gov/oco/ocos225.htm>.

³⁶ Michael Komeli interview.

According to BLS, the path to becoming a fully trained tool and die maker includes four to five years of part-time classroom work in a nearby community or technical college—while working full-time—and on-the-job training. The course work and training are often structured around an apprenticeship program in which students work a 40-hour week in a tool and die setting while attending classes at night.

This type of training is necessary for tool and die makers to work with CAD/CAM and CNC machine tools, which are the basic high-technology components in most tool and die shops today. Even after the apprenticeship, workers will continue training and usually specialize in a particular area, choosing certain types of tools, dies, and molds to apply their expertise.

Other attributes necessary to be a successful tool and die maker include attention to detail and precision, ability to communicate with customers and colleagues, and ability to analyze complex problems, often interconnected to the rest of the product. According to BLS, these skills are best learned from on-the-job training and experience in the profession. For this training and experience, tool and die makers are well paid, earning on average about \$52,000 a year (not including health care and other benefits) and, with overtime, much more.³⁷

The Next Generation

Like other manufacturers, tool and die firms express concern about a looming skills shortage. Older workers, who are likely to have learned their trade mainly on the job, often do not have the skills needed in a highly computerized environment. A recent *Washington Post* profile on manufacturing showed the issue at hand:

“You don’t see anyone advertising for just tool and die maker anymore,” said Tom Whitmore, 59, a tool and die maker who was laid off in 2009 after 33 years at a nearby auto parts maker. “They want CNC skills. For most of them, I can’t apply.”³⁸

The required level of skills is in evidence in a recent advertisement placed by Richardson Electronics, Ltd. in Lafox, IL, which sought an employee who could “design, construct, alter, and repair a wide variety of tools, dies, jigs, fixtures and gauges to very close tolerances. You will participate with a team in the development of new products, perform difficult tool room operations....” The job, paying up to \$26 an hour, requires 8-10 years of experience, proof of an apprenticeship, and “considerable ingenuity in building specialized complex tooling.”³⁹

NTMA surveys show that 95% of tool and die members have openings, even with relatively high U.S. unemployment rates.⁴⁰ A recent survey-based report by Deloitte and the Manufacturing Institute, which is associated with the National Association of Manufacturers, found that 74% of respondents were particularly concerned about the supply of skilled production workers, a

³⁷ “Annual Wages” for the tool and die industry, from BLS, Quarterly Census of Employment and Wages, 2010 and CRS interview on August 5, 2011 with Dave Tilstone, president of the National Tooling and Machining Association (NTMA).

³⁸ “Wanted: Skilled Factory Workers,” *Washington Post*, February 20, 2012.

³⁹ *Careerbuilder.com*, tool and die maker ad, Richardson Electronics, Ltd., Lafox, Illinois, viewed November 7, 2011, http://www.careerbuilder.com/JobSeeker/Jobs/JobDetails.aspx?IPath=QHKTCV0F&ff=21&APath=2.21.0.0.0&job_id=J3T55363Q1ZVVWFVBS4.

⁴⁰ Dave Tilstone interview.

category that includes tool and die makers. More than half of respondents said skills shortages are affecting their level of production and about a third said they compromise quality and productivity.⁴¹

A survey by the Society for Human Resource Management (SHRM) had similar findings. SHRM's 2011 survey reported that employers had the most difficulty in filling positions in manufacturing, as well as in technology and health care. Within manufacturing, the two top professions in short supply were engineers and high-skilled technical employees.⁴²

NTMA has developed a multi-pronged effort to attract new talent into the tool and die industry (see **Table 4**).

Table 4. Industry Skills Building Initiatives

NTMA programs to attract new workers and raise skills levels for existing employees

NTMA Program	Description	Goal
National Robotics League (NRL) http://www.gonrl.org	Through nationwide competitions, NRL focuses high-school teams who design, engineer, build, compete, and learn about robotics and the manufacturing and design skills behind such projects.	NRL seeks to connect participants with local manufacturing companies and to change the perception that manufacturing may not be an interesting and well-paying career path.
Apprenticeship Program	The Advanced Manufacturing Practices and Educational Development program (AMPED) includes training and certification for regional training sites. Standards, best practices, and benchmarks are available to participants through an Internet wiki.	NTMA envisions AMPED wiki to be a one-stop resource for non-proprietary knowledge developed by NTMA members. According to NTMA, participation is self-directed. Regional sites pay a nominal fee for a CD and introductory materials, then form a committee to determine training needs and develop a site plan.
NTMA University http://www.ntma.org/initiatives/education/	This new program offers an online curriculum through participating educational institutions. Students can earn an associate degree.	This program of Internet-based learning, begun on a limited scale in 2011, is designed for entry-level employees and students participating in NRL.

⁴¹ Deloitte and the Manufacturing Institute, *Boiling Point? The Skills Gap in U.S. Manufacturing*, 2011, p. 8, http://www.themanufacturinginstitute.org/~/_/media/A07730B2A798437D98501E798C2E13AA.ashx.

⁴² Julie Bennett, "Demand is High for Skilled Job Seekers," *Wall Street Journal*, November 7, 2011.

NTMA Program	Description	Goal
National Institute of Metal Working Skills (NIMS) https://www.nims-skills.org/web/nims/home	NIMS was formed in 1995 by metalworking trade associations. It establishes industry skills standards, certifies individuals against the standards, and accredits training programs that meet quality requirements.	NIMS has developed national skills standards for 24 operational areas in the U.S. metalworking industry, such as tool die and mold making. It is accredited by the American National Standards Institute (ANSI).

Source: National Tooling and Machining Association and National Institute of Metal Working Skills.

The NTMA priorities on training of existing workers and attracting new talent reflect the BLS projections for this industry. BLS forecasts that employment of tool and die makers should decline modestly (by about 8%) by 2018 because of automation and ongoing foreign competition. BLS notes, however, that “excellent job opportunities are expected” as many openings will result from worker retirement. The BLS report confirms that many employers are having trouble filling positions and that in the future, this shortage may well persist:

The number of workers receiving training in this occupation is expected to continue to be fewer than the number of openings created each year by tool and die makers who retire or transfer to other occupations. A major factor limiting the number of people entering the occupation is that many young people who have the educational and personal qualifications necessary to learn tool and die making usually prefer to attend college or do not wish to enter production occupations.⁴³

The lack of interest in careers in tool and die making has forced some tool and die makers to find other ways to make their products, primarily by increasing the use of more automated equipment. In some companies, “lights-out” manufacturing has become the norm: a night shift is run with minimal worker involvement. Machines do much of the work that employees do in regular shifts. A Wisconsin tool and die maker notes on its website: “we make sure your tooling is done when you need it — even for short lead times. Our tooling department runs with “lights-out” (24-hour) operation to ensure that your deadlines are met.”⁴⁴ In the absence of skilled workers, such highly automated production may increase.

Federal Policy Issues

Several federal programs are designed to bolster tool and die manufacturing. The Department of Commerce aids tool and die makers through the Manufacturing Extension Partnership (MEP), which advises small manufacturers on how to improve their technology and workforce training, often in conjunction with local community and technical colleges. MEP was established by the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) to assist small and medium sized companies compete more effectively in a global marketplace. It has centers in all 50 states and over 1,300 technical advisers to assist small manufacturers with technology acceleration, supplier

⁴³ BLS, *Occupational Outlook Handbook*.

⁴⁴ “Tool Making,” Inventix Manufacturing, <http://www.inventix.com/toolmaking/index.php>.

development, sustainability, workforce issues, and continuous improvement. It leverages about \$100 million in annual federal funding into a \$300 million program by adding state and local government contributions and industry support. Clients pay fees for the consulting service they receive. According to MEP, over the last five years, it provided consultative services to 65 distinct tooling clients⁴⁵ with 182 business improvement projects.

The level of MEP funding was a congressional issue several years ago, but in FY 2011 and 2012, federal appropriations have provided MEP with a level budget of \$128.4 million; the President's FY 2013 budget request proposes a slight decrease in the program's budget. Some MEP advocates have argued for raising the permissible federal share level to 50% (from 33%), while others have argued for lowering it. Funding and the federal contribution level may be issues debated by Congress this year.⁴⁶

The tool and die industry has emphasized the importance of two pending tax issues. With some machine tools used in production costing up to a million dollars each, the industry supports an extension of bonus depreciation and expensing provisions, which Congress enacted in 2010 and which expire at the end of this year. The Precision Metalforming Association (PMA) contends that passage of the two provisions prompted an immediate increase in tool and die makers' sales.⁴⁷ The industry has also urged creation of a "private government guaranteed accounts-receivable insurance program" to help tool and die makers, as companies may need to wait many months for payment by OEMs.⁴⁸

Because of the industry's role in defense production, the Department of Defense (DOD) supports the American Metalcasting Consortium (AMC)⁴⁹ with a \$2.2 million budget to improve the design and production of critical cast parts. AMC works with industry associations and research institutions to reduce lead times and costs, improve performance, and strengthen the supply chain. One recent project, in collaboration with Ohio State University, led to the use of new software tools so that die casting could be used for a DOD project. The changed process resulted in a 75% cost reduction and a savings of over a million dollars per year, according to AMC.⁵⁰

Tool and die makers also advocate for new federal policies with regard to China and workforce development which would pertain to a wide range of manufacturing:

- A high priority for tool and die maker industry associations, such as NTMA and PMA, is dealing with China and other countries that are alleged to manipulate their currencies. The industry associations contend that currency manipulation is an illegal subsidy and should be considered such under U.S. trade laws.⁵¹ The Senate passed legislation on October 11, 2011 that would address this issue—S.

⁴⁵ Data represent clients in the 333514 NAICS Code (dies, jigs and fixtures). It does not include companies in NAICS 333511 (molds). (NAICS is the North American Industry Classification System.)

⁴⁶ For more information on the MEP program, see CRS Report 97-104, *Manufacturing Extension Partnership Program: An Overview*, by Wendy H. Schacht.

⁴⁷ CRS interview with PMA president Bill Gaskin, January 30, 2012.

⁴⁸ "Access to Credit," *One Voice*, a joint government and public affairs program of PMA and NTMA, http://www.metalworkingadvocate.org/issues_trade_enforcement.asp.

⁴⁹ AMC's website is <http://amc.ati.org>.

⁵⁰ Ibid, "Success Stories".

⁵¹ "Trade Enforcement," *One Voice*, http://www.metalworkingadvocate.org/issues_trade_enforcement.asp.

- 1619, the Currency Exchange Rate Oversight Reform Act. In the House, H.R. 639, the Currency Reform for Fair Trade Act, is similar to legislation passed by the House in 2010, but no action has been scheduled in the House at this time.⁵²
- The tool and die makers' associations⁵³ call for a national manufacturing strategy to be developed between the federal government, industry and educational institutions. The industry has been interested in federal participation in public-private partnerships that would help recruit and train workers in critical metalworking industries. The America COMPETES Act⁵⁴ authorized several new manufacturing programs at the Commerce Department's National Institute of Standards and Technology (NIST), including collaborative manufacturing research pilot grants for partnerships between industry and other educational or research institutions to develop new manufacturing processes, techniques, or materials, but this program has not been funded.

⁵² For more information on legislation and issues related to China's currency, see CRS Report RS21625, *China's Currency Policy: An Analysis of the Economic Issues*, by Wayne M. Morrison and Marc Labonte.

⁵³ NTMA and PMA, "Workforce Training," *One Voice*, http://www.metalworkingadvocate.org/issues_training.asp.

⁵⁴ P.L. 110-69.

Appendix. The Link between Die Making and Auto Manufacturing

The auto industry is the largest user of tools and dies. In the following excerpt from the acclaimed book about the auto industry, *The Machine That Changed the World*,⁵⁵ the authors single out the role of die makers in both the design and building of cars. (The original text includes the footnoted material cited.)

Simultaneous Development

The final technique separating lean from mass production in product development is simultaneous development. To see what we mean by this term, let's take the example of die development. ...Practically every car and light truck built in the world today has a body constructed of stamped steel panels. The heavy metal forms, called dies, needed to press finished body panels out of sheet steel are among the most complex and expensive tools in the industrial world. They are made of exotic steel alloys for extreme strength and hardness and must be formed to tolerances of microns across continuously curving surfaces. What's more, the matching faces of the die (the upper and lower or "male" and "female" elements) must mesh with absolute precision. Otherwise, the sheet steel will tear or even melt to the face of the dies as the two pieces come together under tons of pressure.

The mass-production approach to die-making has been simple: Wait until the product designers give precise specifications for the stamped part. Then, order an appropriate block of steel in the die-production department and cut it, using expensive, computer-driven, die-cutting machines. Because cutting proceeds through many steps involving many machines, this process means that the dies pile up waiting for the next machine to become available. Total development time, from the first day that product designers order a new set of dies until the dies begin stamping panels for production cars, is about two years. By contrast, the best lean producers-and they're all Japanese but no longer only in Japan (Honda is designing and cutting dies for its Marysville, Ohio, plant at Marysville)-begin die production at the same time they start body design. How can they? Because the die designers and the body designers are in direct, face-to-face contact and probably have worked together in previous product-development teams.

The die designers know the approximate size of the new car and the approximate number of panels so they go ahead and order blocks of die steel. Then they begin to make rough cuts in the steel, so it's ready to move to final cutting as soon as the final panel designs are released.

This process, of course, involves a considerable degree of anticipation. The die designer must understand the panel-design process as well as the panel designer does and be able to anticipate accurately the panel designer's final solution. When the die designer is correct, development time is drastically shortened. When the die designer is wrong (an infrequent occurrence), the company pays a cost penalty. Still, the original schedule can be met by giving the catch-up die priority routing through the cutting process.

Also, the lean die makers seem to be much better at scheduling production in the die-cutting shop... The die cutters have special, quick-change cutting tools, allowing one machine to handle many different types of cuts, so the dies that are being cut spend much less time in queues.

What's the end result of this intense communication between panel designers and die makers plus accurate anticipation by the die makers and clever scheduling of flexible cutting machines? It means that the best lean producers in Japan (and in Ohio) can produce a complete set of production-ready dies for a new car in one year, exactly half the time needed in typical mass-production die-making.⁵⁶ Not surprisingly, this process requires fewer tools, lower inventories (since the key element, the expensive die steel, is in the shop only half as long), and less human effort.

⁵⁵ James P. Womack, Daniel T. Jones, and Daniel Roos, "Designing the Car," in *The Machine That Changed the World* (New York: Rawson Associates, 1990), pp. 116-117.

⁵⁶ Kim B. Clark and Takahiro Fujimoto, "Overlapping Problem-Solving in Product Development," in K. Feddows, *Managing International Manufacturing*, 1989, Table 2.

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