Statement of Findings: Sizing Nanotechnology's Value Chain

Companies struggle to quantify their specific revenue opportunities in nanotechnology. This confusion results from the widespread view that nanotechnology is a holistic industry. It isn't – it's an essential enabler that will impact all manufactured goods. Lux Research's Three Truths of Nanotechnology cut through the confusion:

1) **There is no "nanotechnology market."** There is a nanotechnology value chain, going from nanomaterials (e.g., clay nanoparticles) to nanointermediates (e.g., composite materials made from the clay nanoparticles) to nano-enabled products (e.g., the 2004 Chevrolet Impala, with side body moldings made from the nanocomposite material) (see Figure 1).

2) **Not all nanotechnology is new.** Emerging nanotechnology is developing against a backdrop of well-understood, established nanotechnology. Examples of the latter include synthetic zeolites as well as currently shipping microchips with feature sizes under 90nm (see Figure 2).

3) **Many products incorporating nanotechnology will be only marginally profitable.** Most nanomaterials will rapidly become commodities with operating margins capped at the high single digits typical of specialty chemicals. Profits from nanointermediates and nano-enabled products will vary widely, following product category margins.

Corporations that have internalized the Three Truths of Nanotechnology are already spending more than $3.8 billion in R&D on nanotechnology this year. Many already have products on the market.

Nanotechnology is approaching a phase change that will see it spread exponentially across manufactured goods in the next 10 years. In 2004, $13 billion worth of products will incorporate emerging nanotechnology, less than one-tenth of 1% of global manufacturing output. In 2014, we project that this figure will rise to $2.6 trillion – 15% of manufacturing output in that year (see Figure 3). Nano-enabled products will dominate revenues, but nanointermediates will account for the greatest share of profit due to margins more than three times higher (see Figure 4).

- From 2005 to 2009, commercial breakthroughs will unlock markets for emerging nanotechnology. High-volume, high-margin applications will drive down the cost of nanomaterials. Nanointermediates will take off in electronics and information technology (IT), driven by microchips patterned using new nanolithography techniques. Nano-enabled products will break out in automobiles, portable electronics products, and drug reformulations. In 2009, revenues across the value chain will reach $278 billion.

- From 2010 to 2014, emerging nanotechnology will become commonplace. Nanomaterials will find new homes both as replacement materials and as enablers of new products. Nano-intermediate products in electronics and IT will be joined by burgeoning applications in other

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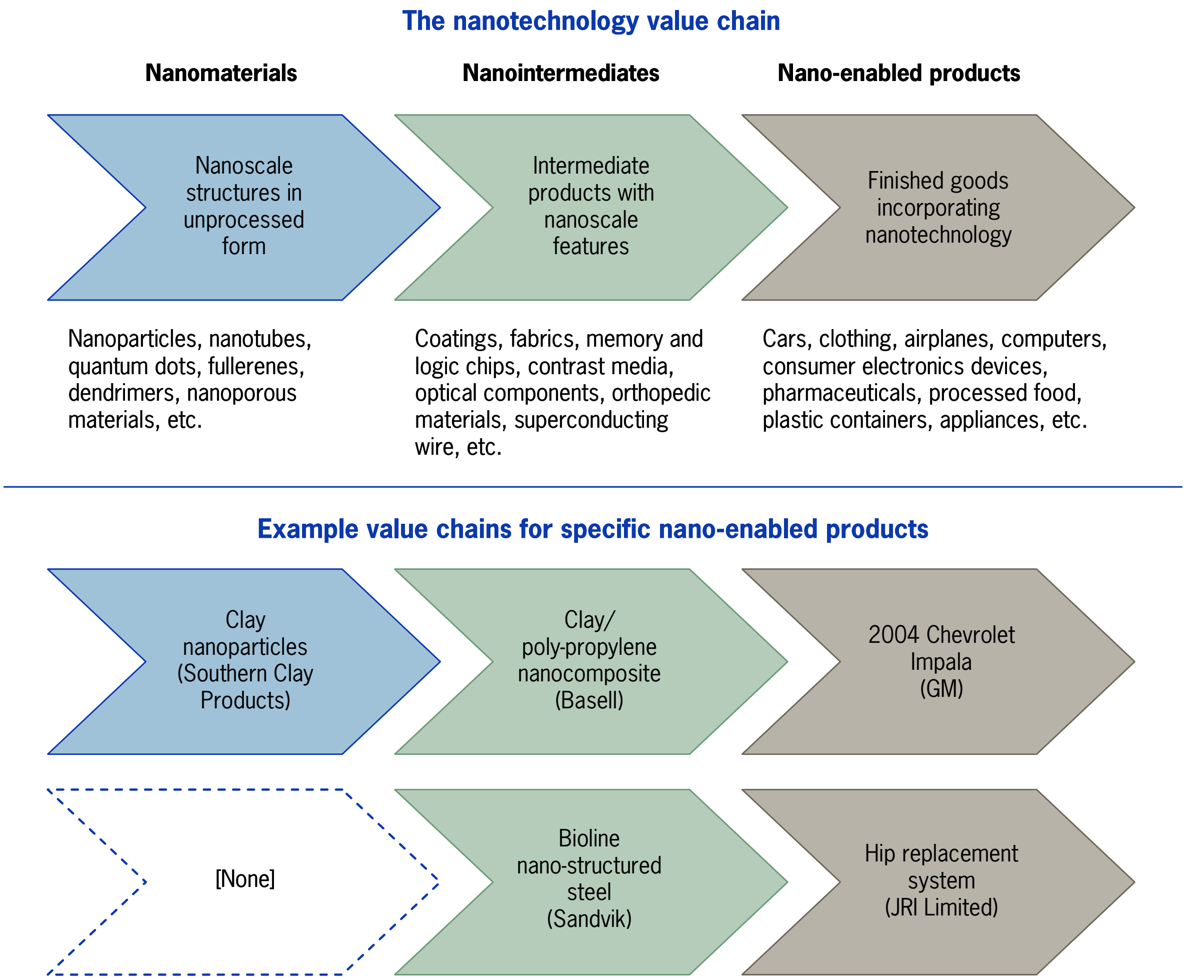
Fig. 1: Nanotechnology adds value across industry value chains in three stages



product categories from structural metal to orthopedic implants. In 2014, manufacturing output incorporating emerging nanotechnology will total $2.6 trillion – 4% of general manufacturing output, 50% in electronics and IT, and 16% in healthcare and life sciences.

- Revenues of products incorporating nanotechnology will exceed biotechnology by 10 times and have an economic impact on par with information technology and telecom.

Methodology

For "Sizing Nanotechnology's Value Chain," Lux Research built bottom-up, top-down, and evolutionary models of 42 product segments impacted by nanotechnology. The report team populated the models through exhaustive secondary research; interviews with more than 100

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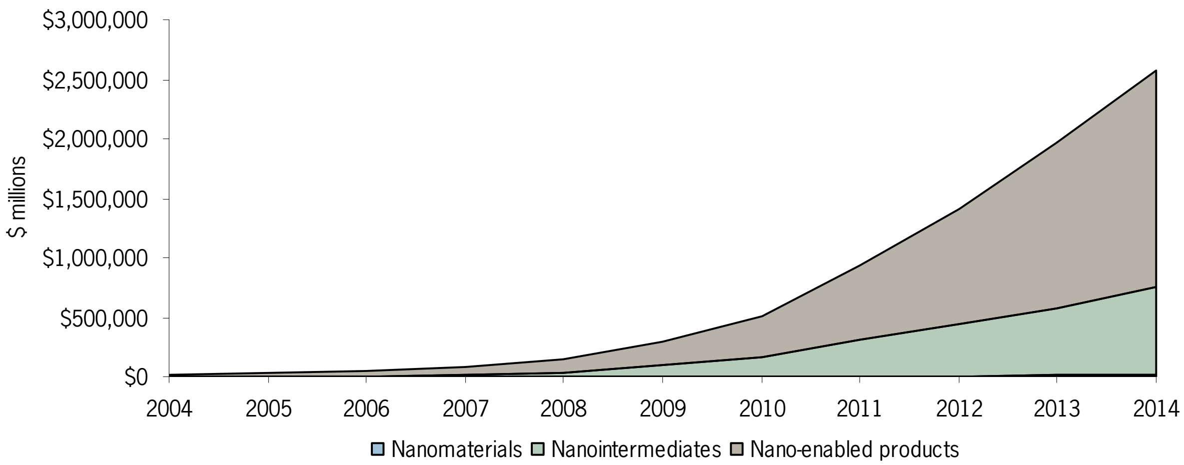
Fig. 2: Established and emerging nanotechnology have little in common

	Established nanotechnology	Emerging nanotechnology
Processes	Well-understood	Poorly understood
Growth rates	Single-digit	Double- to triple-digit
Profit margins	Set by entrenched competitors	Set by new entrants
Changes	Incremental	Disruptive
Level of risk	Low	Very high
Potential return	Low	Very high
Nanomaterial examples	Synthetic zeolites, naturally occurring nanoparticles	Nanotubes, quantum dots, dendrimers
Nanointermediate examples	90nm semiconductors, ferrofluids, CMP slurries, GMR hard drive heads	Nano-coated fabrics, nanostructured steel, nanoscale drug delivery carriers
Nano-enabled product examples	Ancient Egyptian pottery (naturally occurring nanoparticles), high-end audio speakers (ferrofluids)	Appliances with silver nanoparticle coatings, bicycle frames made from nanotube composites

Fig. 3: Global sales of products incorporating *emerging* nanotechnology, by value chain stage, 2004 to 2014



	2004	2006	2008	2010	2012	2014	CAGR
Nanomaterials	$134	$288	$1,304	$2,784	$5,947	$12,892	58%
Nanointermediates	$851	$7,888	$37,890	$160,750	$442,020	$741,864	97%
Nano-enabled products	$12,001	$43,455	$110,944	$344,204	$962,511	$1,818,126	65%
Total	**$12,986**	**$51,631**	**$150,138**	**$507,738**	**$1,410,479**	**$2,572,883**	**70%**

Note: Column values may not add to total due to rounding.

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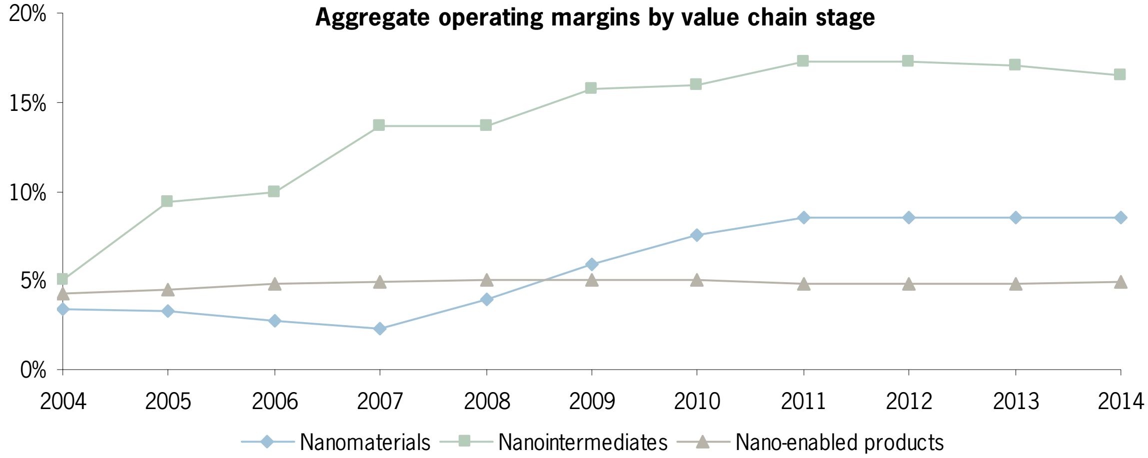
Fig. 4: Aggregate operating profits margins from products incorporating *emerging* nanotechnology, 2004 to 2014



	2004	2006	2008	2010	2012	2014
Nanomaterials	3.4%	2.7%	3.9%	7.5%	8.6%	8.6%
Nanointermediates	5.0%	10.0%	13.7%	15.9%	17.2%	16.5%
Nano-enabled products	4.3%	4.8%	5.0%	5.0%	4.8%	4.9%

executives, researchers, and academics working to commercialize nanotechnology; and integration of macroeconomic data from organizations such as the U.S. Bureau of Economic Analysis and the World Bank. Additionally, Lux Research partnered with UK-based Volterra Consulting – founded by Paul Ormerod, influential economist and author of "Butterfly Economics" – to build advanced evolutionary models that measure how nano-enabled solutions compete for market share with alternatives.

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