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Working Paper 18-071

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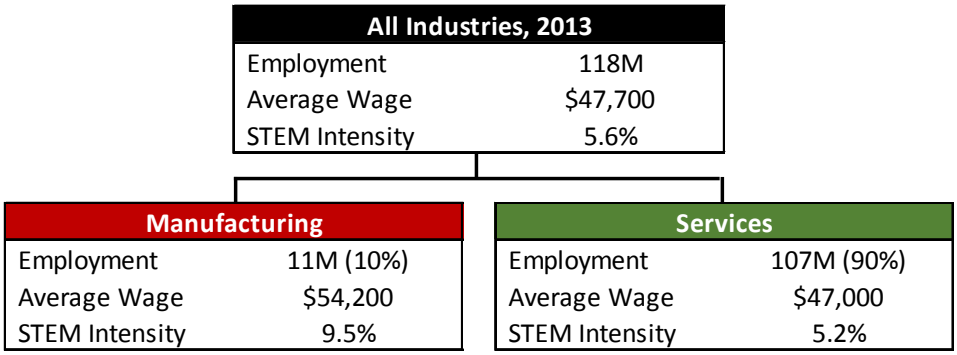
Summary. The debate in economic policymaking about the drivers of innovation and job creation has long been centered on manufacturing versus services. The predominant view is that manufacturing drives innovation, wages, and growth, and that services provide less innovation and lower-wage jobs. We propose an alternative framework that focuses on the suppliers of goods and services to businesses and the government: the "supply chain economy". Our research shows that by categorizing the economy into Supply Chain versus Business-to-Consumer industries, a different picture emerges. The supply chain industries are a distinct category of the economy that is important to innovation and well-paid jobs. In particular, the supply chain services have the highest wages and intensity of STEM jobs in the U.S., and have experienced rapid growth in employment and wages in the last two decades. However, supply chain industries face unique challenges that may require new policy solutions from the public and private sector. Critical initiatives could focus on improving their access to skilled labor, buyers, and capital.

1. The Dominant Narrative: Manufacturing Drives Innovation

A long academic and policy debate has focused on the role of the manufacturing capacity of a country on its economic and innovative performance. The predominant view is that the capacity to manufacture goods drives innovation because of externalities associated with the production process that improve the ability to innovate.[3] Recently, the debate has focused on increasing "advanced manufacturing": innovative manufacturing technologies and related processes, such as advanced materials, nanotechnology, and smart production processes.[4]

The innovation debate has remained largely centered on manufacturing because it accounts for the vast majority of patents, while services tend to be viewed as low technology and lower-wage. Indeed, manufacturing has a greater intensity of Science, Technology, Engineering and Math (STEM) jobs than services (the percentage of employment in STEM was 9.5% vs. 5.2%).[5]

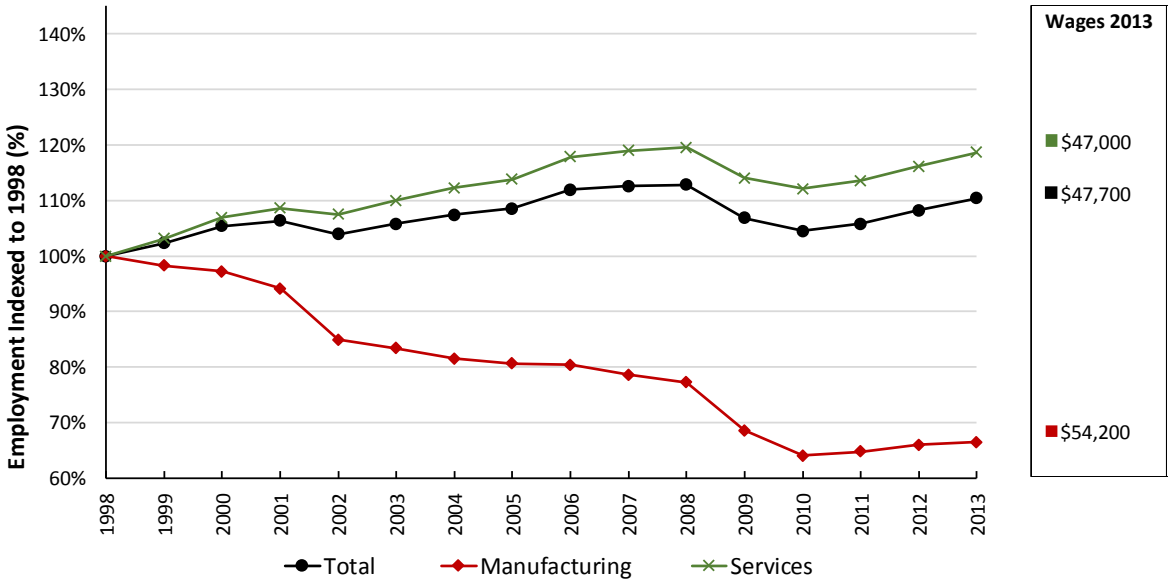
Figure 1. Manufacturing versus Services Framework



Note: Private employment and wages (excluding self-employed). Manufacturing includes NAICS codes 31-to-33. Sourced from Delgado and Mills (2017).

But the focus on manufacturing has resulted in a pessimistic view of the economy reflecting the decline in higher-wage manufacturing jobs.[6] During 1998-2013, manufacturing employment declined by more than 30%, while services grew by almost 20% (Figure 2).

Figure 2. Pessimistic View of the Economy: Bringing Manufacturing Back



Note: Private employment and wages (excluding self-employed). Sourced from Delgado and Mills (2017).

The policy response – perhaps misguided – has been to focus on initiatives for "bringing manufacturing back" in order to create good jobs. However, manufacturing currently comprises only around 10% of employment (Figure 1). On the other hand, services account for 90% of employment, and are extremely heterogeneous – ranging from engineering and cloud computing to retail and restaurants. In this policy briefing, we present a new framework that allows us to characterize the different types of services in the economy, and show the potential in some of the service subcategories for creating a growing number of high wage, high technology jobs.

2. A New and Complementary Framework: The Supply Chain Economy

To better understand the drivers of innovation and economic performance, we propose a new framework that focuses on the suppliers of goods and services to businesses and the government: *the supply chain economy*. Suppliers have three attributes that make them particularly important for the innovation and growth of a country:

1. They produce specialized inputs that can create learning externalities and improve the efficiency (speed, cost, and diffusion) of the innovation process.[7]
2. They often have downstream linkages with multiples industries (e.g., semiconductors or cloud computing services). Hence, innovations developed by suppliers may diffuse more broadly to other industries.
3. Their customers are more geographically concentrated than consumers. Thus, suppliers and their customers can benefit from co-location and generate external economies that contribute to innovation and growth.[8]

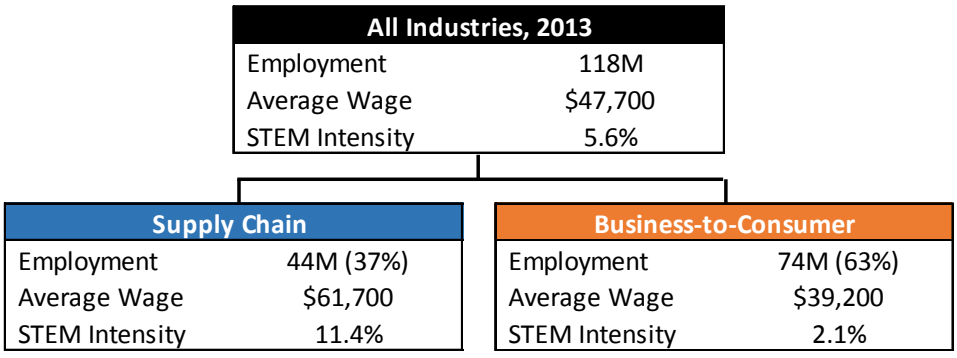
To quantify the economic importance of suppliers, we introduce a new industry categorization that separates supply chain (SC) industries (i.e., those that sell their goods and services primarily to businesses or government) from business-to-consumer (B2C) industries (i.e., those that sell primarily to consumers). We use measures of industry-level sales for personal consumption from the Benchmark Input-Output Accounts to categorize narrowly defined industries as SC versus B2C.[9]

We also combine our framework with the Manufacturing versus Services, and Traded versus Local industry categorizations to analyze specific subcategories of the economy.[10] In particular, we divide the supply chain economy into SC Traded Manufacturing industries (like *Semiconductor Manufacturing*), SC Traded Services industries (like *Engineering Services*), and SC Local industries (like *Janitorial Services*). Using this framework, we offer new insights on suppliers as a distinct segment of the economy.

3. The Supply Chain Economy Matters for Economic Performance

While there is an important literature that focuses on the management of the supply chain of particular industries and firms, there is a lack of quantification of the suppliers to the economy and their types.[11] We find that the supply chain economy is a distinct category in terms of size, average wages, and innovative activity (Figure 3). Supply chain industries are a large segment of the economy, with 37% of U.S. private employment in 2013. They have wages 57% higher than those in B2C industries ($61,700 versus $39,200). They also have a greater STEM intensity (11% in SC industries versus 2% in B2C industries), and they account for the majority of STEM jobs and patents.[12] Our estimates are the first comprehensive attempt to measure the economic importance of the supply chain economy.

Figure 3. Supply Chain versus Business-to-Consumer Framework



Source: Delgado and Mills (2017).

3.1 In Today's U.S. Economy Suppliers Are Not Just Manufacturers

We combine our categorization with Manufacturing versus Services to assess different subcategories of suppliers (Figure 4). One key finding is the economic importance of the SC Services industries versus SC Manufacturing industries: they are four times larger in terms of

employment; they also have 11% higher wages, and similar STEM intensity (11.5%). This result challenges most prior work focusing on a narrow view of suppliers as manufacturers.

Our framework also helps to explain the heterogeneity in services. Supply chain services have significantly higher wages and STEM intensity than B2C services (62% higher wages and 5 times higher STEM intensity). The lower wages and technology intensity of the B2C services are in part due to "Main Street" services that serve the local markets (like beauty salons, car repair, retail, and restaurants).

Figure 4. The Supply Chain versus B2C Subcategories in Manufacturing and Services, 2013

	Supply Chain		Business-to-Consumer	
Manufacturing	Employment	8.7M (7%)	Employment	2.6M (2%)
	Average Wage	$56,600	Average Wage	$46,200
	STEM Intensity	11.1%	STEM Intensity	4.2%
Services	Employment	35.5M (30%)	Employment	71.5M (60%)
	Average Wage	$63,000	Average Wage	$38,900
	STEM Intensity	11.5%	STEM Intensity	2%

Source: Delgado and Mills (2017).

3.2 Supply Chain Traded Services Have the Highest Wages and STEM Intensity

The importance of supply chain services is amplified when we examine the traded economy (i.e., industries that sell their output across regions and countries). By separating traded suppliers into manufacturing and services (Figure 5), we find that the subcategory of Supply Chain Traded Services is large and has the highest wages ($80,800, which is 70% higher than the average wage in the economy) and STEM intensity (19%) in the U.S. economy.

While these services are technologically advanced (with more than 50% of all the STEM jobs), they have few patents because innovations in services are not easily patentable. Therefore, patent-based indicators will underestimate the increasingly important contribution to innovation of high-tech services (e.g., engineering, design, R&D, software, financial, and logistics services).[13]

Figure 5. The Supply Chain versus B2C Subcategories within the Traded Economy, 2013

	Supply Chain Traded		Business-to-Consumer Traded	
Manufacturing	Employment	8.1M (7%)	Employment	2.4M (2%)
	Average Wage	$57,400	Average Wage	$47,200
	STEM Intensity	11.7%	STEM Intensity	4.5%
Services	Employment	18.7M (16%)	Employment	13.4M (11%)
	Average Wage	$80,800	Average Wage	$57,800
	STEM Intensity	19.3%	STEM Intensity	6.1%

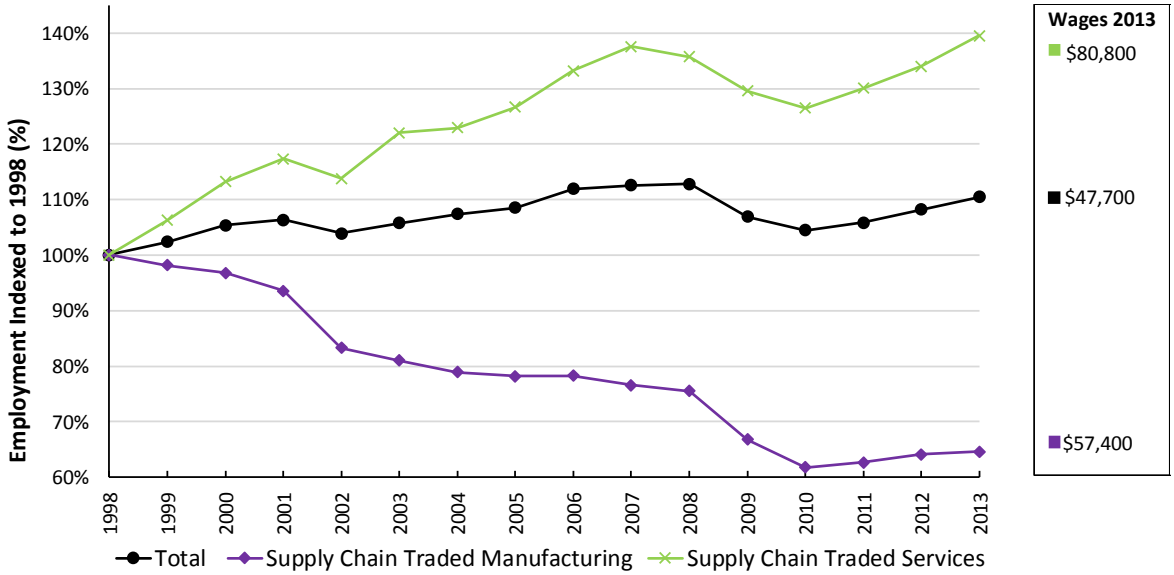
Source: Delgado and Mills (2017).

3.3 The Supply Chain Economy Has Evolved towards Well-Paid Traded Services

In terms of growth, employment in the supply chain economy has been evolving away from manufacturing and towards services for the period under examination (1998-2013). Suppliers of traded services have been experiencing high growth in employment and wages. While many jobs were lost in SC manufacturing, many high-wage jobs were created in SC traded services (Figure 6). This compositional change reflects the increasing importance of some service industries, like data processing and hosting, design, engineering, marketing, logistics, and software services. It also reflects the evolution towards services that some big firms have experienced over the past few decades (e.g., IBM, Intel, and Dell Technologies).

By separating high-tech and high-wage SC traded services from low-tech and low-wage B2C Main Street services (like retail and restaurants), we are able to offer a more optimistic view of today's service-oriented economy.

Figure 6. Optimistic View of the Economy: Service Suppliers Have Created Many Well-Paid Jobs



Source: Delgado and Mills (2017).

4. Proposed Policy Areas to Foster the Supply Chain Economy

Given the importance of the supply chain economy, there is an opportunity for policy makers to ask a new set of questions: What are the particular needs of firms in the supply chain economy, and how do proposed policy initiatives affect this critical segment? Over the past decades, efforts across multiple administrations with bipartisan support have recognized the importance of manufacturing suppliers: efforts such as the Manufacturing Extension Partnership (created in 1988);[14] the more recent American Supplier Initiative; and programs to foster innovation in the supply chain of automakers.[15] However, policy work to date has focused primarily on the supply chain of manufactured goods (e.g., automakers and their suppliers of auto parts). We broaden the discussion by considering the unique challenges that both manufacturing and particularly

service suppliers may face with regard to accessing three critical resources: skilled labor, buyers, and capital.

4.1 Access to Skilled Labor

- *The supply chain economy has a distinct labor composition with a high concentration of STEM jobs.* It is well-established that STEM jobs are important for innovation and growth.[16] Supply chain industries, particularly those in traded services, rely heavily on skilled STEM workers who have been in short supply. This suggests that further policy emphasis on STEM training is warranted, including public and private sector efforts to train a larger and diverse talent pool and to increase the program levels on high skilled immigration.

- *Inter-firm collaboration in creating a talent pool.* Partnerships among suppliers and lead buyers in hiring and training, rather than competition for talent, could support suppliers.[17] More broadly, policies that promote collaboration between employers and the local colleges and universities that provide talent could lead to a more effective talent pipeline.

4.2 Access to Buyers

- *Supplier-Buyer co-location and collaboration.* Suppliers produce inputs that are part of the value chain of other businesses. Hence, suppliers could benefit especially from co-locating with their buyers within regional clusters.[18] Industry clusters cannot be created, but can be catalyzed and strengthened by supporting institutions (i.e., collective efforts by firms, public entities and other institutions to improve the competitiveness of regional clusters). Regional and cluster initiatives could foster supplier-buyer networks in a location in ways that ensure both collaboration and fair competition among firms. Organizations like the Massachusetts Biotechnology Council (MassBio) have a long tradition of creating opportunities for suppliers and buyers to connect and collaborate.[19]

4.3 Access to Capital

- *Capital for STEM-intensive suppliers of services.* Access to capital can be particularly difficult for firms that produce innovative services because they often cannot be patented. Thus, it may be harder to signal quality and raise capital. Possible solutions include guarantees or credit support for suppliers seeking capital from local or federal governments or industry partners. This issue is even more pressing given the importance of STEM-intensive service suppliers.

- *Vulnerability to demand shocks.* Suppliers are vulnerable to shocks faced by their buyers (import shocks, economic crises) because these shocks can be amplified from the buyers to the suppliers (the *bullwhip effect*).[20] Public and private initiatives that mitigate the working capital costs of suppliers –like the QuickPay and SupplierPay federal programs– and policies that encourage larger companies to create partnerships with their domestic supply chains could foster growth and resilience in this critical part of the economy.[21]

By supporting the supply chain economy through targeted policies, government and businesses could both do their part to create the innovation and well-paying jobs that the American economy needs. What practices would be most effective in achieving these goals is a fruitful area for future research.

5. Conclusion

A new categorization of U.S. industries has revealed a large and dynamic supply chain economy which plays a crucial role in innovation and in the creation of well-paid jobs. The traditional emphasis on manufacturers misses the high wage and STEM intensity of supply chain traded services. This changes the innovation narrative from being focused primarily on manufacturing to being centered on the chain of suppliers of goods and services. Given these new insights, we believe that policy options that support suppliers and their access to skilled labor, buyers and capital could have an important role in fostering innovation and economic growth.

To further inform policy makers and add to the understanding of the supply chain economy, two future areas of work are critical. The first is generating better data for services, including new measures of innovation that recognize that technology-intensive services may have a much higher contribution to innovation than predicted based on their low patenting. The second is mapping and examining the supply chain firms and their supplier-buyer networks to better understand the innovation process.

End Notes

[1] This paper builds on the MIT Sloan School working paper "A New Categorization of the U.S. Economy: The Role of Supply Chain Industries in Innovation and Economic Performance," by Mercedes Delgado and Karen Mills (2017). We are grateful to Rich Bryden, Aaron Mukerjee, and Christopher Rudnicki for excellent research assistance. We thank Scott Stern, Susan Helper, Cathy Fazio, Fiona Murray, and Jim Utterback for their helpful suggestions.

[2] Mercedes Delgado, Senior Lecturer and Research Scientist at MIT Sloan and MIT Lab for Innovation Science and Policy; Karen G. Mills, Harvard Business School Senior Fellow and former Administrator, U.S. Small Business Administration (2009–2013).

[3] See e.g., Rosenberg, N. (1963). "Capital Goods, Technology, and Economic Growth." *Oxford Economic Papers, New Series* 15 (3), 217–227; Dertouzos, M.L., R.K. Lester, R.M. Solow, and the MIT Productivity Commission (1989). "Made in America: Regaining the Productive Edge," MIT Press; and Pisano, G.P. and W.C. Shih (2009). "Restoring American Competitiveness," *Harvard Business Review* 87 (7/8), 114–125.

[4] The Advanced Manufacturing Partnership (AMP) was created in 2011 by the White House to foster collaboration between industry, universities, and the government in innovative manufacturing. See Berger, S. (2013). "Making in America: From Innovation to Market." MIT Press; and Bonvillian, W.B. (2013). "Advanced Manufacturing Policies and Paradigms for Innovation," *Science* 342 (6), 1173–1175.

[5] The STEM intensity (or percent of employment in STEM) of an industry category captures its technological intensity. Delgado and Mills (2017) uses the STEM occupation definition developed by Hecker (2005). See Hecker, D. (2005). "High-technology Employment: a NAICS-based Update," *Monthly Labor Review*, 57–72.

[6] This decline in manufacturing employment has been in part attributed to an increase in imports from China. See Acemoglu D., D. Autor, D. Dorn, G. Hanson, and B. Prince (2016). "Import Competition and the Great U.S. Employment Sag of the 2000s," *Journal of Labor Economics* 34 (1), 141–198.

[7] See e.g., Rosenberg's (1963) work on the role of the producers of specialized capital goods in innovation.

[8] See e.g., Glaeser, E.L. and W.R. Kerr (2009). "Local Industrial Conditions and Entrepreneurship: How Much of the Spatial Distribution Can We Explain?," *Journal of Economics and Management Strategy* 18 (3), 623–663; and Delgado, M., M.E. Porter, and S. Stern (2014). "Clusters, Convergence, and Economic Performance," *Research Policy* 43 (10), 1785–1799.

[9] In Delgado and Mills (2017), industries (6-digit NAICS codes) that sell less than one-third of their output to Personal Consumption Expenditure (PCE) are classified as SC, and the rest are classified as B2C. They implement an extensive

validation analysis that considers alternative SC vs. B2C definitions. The large economic importance of the supply chain economy, and especially traded services, is very robust to using the alternative definitions.

[10] Traded industries are those that sell their output across regions and countries versus industries that primarily serve the local market (e.g., retail). This categorization was developed by Porter, M.E. (2003). "The Economic Performance of Regions," *Regional Studies* 37, 549–78.

[11] See e.g., Cusumano, M.A. and A. Takeishi (1991). "Supplier Relations and Management: A Survey of Japanese, Japanese-Transplant, and U.S. Auto Plants," *Strategic Management Journal* 12(8), 563– 588; Gereffi, G., J. Humphrey, and T. Sturgeon (2005). "The Governance of Global Value Chains." *Review of International Political Economy* 12 (1), 78–104; and Helper S. and J. Kuan (2016). "What Goes on Under the Hood? How Engineers Innovate in the Automotive Supply Chain," NBER Working Paper 22552.

[12] See Delgado and Mills (2017) for the analysis of the patenting activity in the supply chain and B2C subcategories.

[13] Relevant studies of the contribution of supply chain services to innovation include, among others: Gawer, A. and M.A. Cusumano (2002). *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation,* Harvard Business School Press; Sheffi, Y. (2012). *Logistics Clusters: Delivering Value and Driving Growth*, Cambridge, Massachusetts: MIT Press; Bitner, M.J., A.L. Ostrom, and F.N. Morgan (2008). "Service Blueprinting: A Practical Technique for Service Innovation," *California Management Review* 50 (3), 66–94; and Helper and Kuan (2016).

[14] The Manufacturing Extension Partnership (MEP) is part of the Department of Commerce's National Institute of Standards and Technology. Information on the MEP is available at https://www.nist.gov/mep.

[15] These initiatives are discussed at The Executive Office of the President (EOP) and the U.S. Department of Commerce (2015). "Supply Chain Innovation: Strengthening America's Small Manufacturers" (last accessed in July, 2015), http://www.esa.doc.gov/sites/default/files/supply_chain_innovation_report.pdf.

[16] Moretti, E. (2012). *The New Geography of Jobs,* Mariner Books.

[17] Successful partnerships between Japanese automakers and their suppliers have long been documented in the supply management literature (Cusumano and Takeishi, 1991). Toyota's *relational* contracts with their suppliers have been associated with more effective innovation by the automaker and its suppliers, in contrast to General Motors' short-term, arm's length relationships with suppliers. Lead firms should consider methods that allow them to foster and value collaborations with suppliers. See Helper S. and R. Henderson (2014). "Management Practices, Relational Contracts, and the Decline of General Motors," *Journal of Economic Perspectives* 28 (1), 49–72.

[18] Delgado, M. and M.E. Porter (2016). "Clusters and the Great Recession," DRUID Conference Paper.

[19] The Massachusetts Biotechnology Council is a not-for-profit organization founded in 1985 that supports companies in biopharmaceuticals and related life sciences clusters. See http://www.massbio.org.

[20] Forrester, J.W. (1961). *Industrial Dynamics*, MIT Press.

[21] Helper, S., J. Nicholson, and R. Noonan (2015). "The Economic Benefits of Reducing Supplier Working Capital Costs." Web. Accessed on July 2015. http://www.esa.doc.gov/sites/default/files/supplierpayv25.pdf.