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# A Prediction of U.S. Knit Apparel Demand: Making the Case for Reshoring Manufacturing Investment in New Technology

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## ABSTRACT

*Purpose of this paper is to demonstrate the demand of knit apparel products, and make a case for implementation of new knitting technologies to further bolster the U.S. reshoring movement. Time-series forecasting with ARIMA model was applied in analyzing the available data. Major findings include that there is a potential for picking knit apparel as a sustained reshoring efforts based on the consumer demand for these product categories and a product category for which a major investment is warranted.*

*This study will shed some light on knit apparel imports which have not been studied in the past as a possible area of investment for reshoring and technology development.*

*Keywords: knit apparel industry, time-series analysis, reshoring, U.S. manufacturing, imports and demand*

## INTRODUCTION

Since the decline of the United States textile manufacturing in the 1980s, many experts in the industry are skeptical that the textile industry will ever truly return with "reshoring" efforts. Innovation in business has become crucial to the survival of a company and economy of countries. The textiles industry is no different. We can see that innovation has taken many turns over the last twenty years, and particularly interesting is the development of new knitting technologies. Several of these new innovations have been touted as the "way of the future" for the textile industry, but data does not exist to prove these new technologies are better business models than existing ones due to the infancy of this technology.

The purpose of this study is to contribute towards the claim that the knit apparel market is growing and should receive investment of new technologies. Historical import and sales data related to the knit apparel industry will be analyzed by the use of ARIMA time-series modeling. With this

analysis, a case will be made for the investment of new knitting technologies and reshoring of this category for United States-based apparel manufacturing.

## THE RESHORING OBJECTIVE

Reshoring of the United States manufacturing sector has been a topic of interest in recent years as labor costs continue to rise in foreign producing countries, most notably in China. Walmart has even joined this movement and has spearheaded an initiative to produce more of their merchandise in the United States by committing to purchase $250 billion in American-made goods by the year 2023. The argument has been made, however, that reshoring does not create as many local jobs as we'd like. (Ng, 2015) Because labor is relatively more expensive in the United States, companies must compensate the difference with a smaller labor force. This is where automation of a production stream is of the utmost importance. Without also implementing a new technology with high automation, there is little hope for any type of manufacturing renaissance the American people have hoped for. (Fox, 2016)

There have been skeptics to the reshoring movement, as the numbers do not support a full shift to manufacturing in the United States. Claiming that Chinese labor prices are skyrocketing to unbearable levels has been somewhat refuted in recent months. The Information Technology & Innovation Foundation recently estimated the wages of Chinese workers to be just 12 percent of average U.S. wages in 2015. Though labor costs are rising in China, the comparison to United States wages is still no contest. To avoid these increasing labor costs, companies are generally turning to produce in other Asian countries, rather than turning to reshoring in the United States. (Tate, 2014)

Many experts would argue the purpose of reshoring is to bring jobs back to the United States which have been eliminated due to outsourcing of labor. (Ng, 2015) It is also argued that the true definition of reshoring is merely to bring production back to the U.S. and the "jobs factor" is only a political one. The jobs that are being "brought back" to America are not the jobs they are being replaced in other countries. Instead, the U.S. must rely on the highly-skilled labor which resides in this country and technologies that automate manufacturing as much as possible.

There still exists several factors that contribute towards the decision of a company to invest in reshoring of their manufacturing: landed cost, hidden cost and risk management. Having a complicated and lengthened supply chain poses many risks that have not been considered in the skeptic's argument against reshoring. (Barrentine & Whelan, 2015)

What is often ignored and downplayed is the increasing trade deficit, which is of high concern to the stability of the U.S. economy. Figure 1 shows the United States trade deficit from 1992 to 2016. (U.S. Census Bureau, 2016) It shows a recent uptick in the trade deficit since 2008, yet the general trend line is still increasing at an alarming rate. This trade deficit has the potential to devalue the exchange rate of the U.S. dollar and upend the still-recovering U.S. economy. (Gabberty & Vambery, 2014) With careful consideration, reshoring efforts have the potential to turn the trade deficit around. (Barrentine & Whelan, 2015) It will be a slow process, without instant gratification. But like many other virtues in life, the best things are worth waiting for.

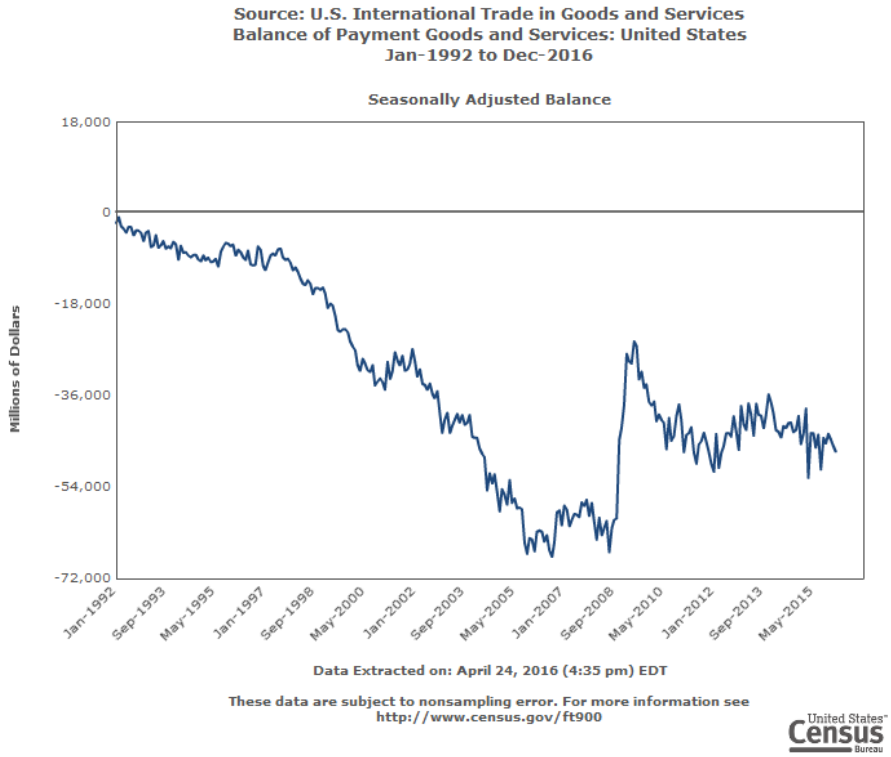



**Figure 1. United States Trade Deficit of Goods & Services, Retrieved from U.S. Census Bureau**

IbisWorld projects import penetration to increase in the manufacturing sector, at an estimated value in 2016 of 31.6%. Due to the stabilizing economy, outsourcing has increased already. Experts are anticipating that this trend will continue, but also benefit the U.S. manufacturing sector, where the product focus will shift to higher quality and high-value items. (IBISWorld, 2016)

## NEW KNITTING TECHNOLOGIES

Taking into consideration the need for automation in order for U.S. reshoring efforts to succeed, the textile industry has made great strides in this respect through knitting technologies. Complete garment knitting has been touted as the "way of the future" and experts in the field agree that this technology will be the most wide stream method of knitting in the 21st century. (Tait, 2008; Kanakaraj & Ramachandran, 2010)

Complete garment knitwear is a fascinating and cutting edge technology that allows a seamless garment to be knit in one piece. This eliminates additional production steps and wasted material that are typical of cut & sew methods. WholeGarment® technology was first introduced in 1995 at ITMA, by Shima Seiki and since has had several iterations by the Japanese machine manufacturer. Stoll of Germany has also proved themselves as a market leader in this technology also by creating their own version named- Knit n' Wear®. (Tait, 2008) Other players have also come into this technology scene for the overwhelming truth that, this is where the industry is heading.

Seamless knitwear, is arguably the most innovative of all knitting ways and has been stated as being capable of reducing production costs up to forty percent. With minimal processing steps upon completion of a knitted item, the quantity of labor force requirements are significantly less for this method of knitting. (Isaacs, 2005) Complete garment knitting is technically very complex

and requires a highly-skilled workforce to operate the machines and software. (Eckert, 2001) As stated before, the United States benefits in its degree of skilled workers- they need only the right kind of training for complete garment knitting to gain traction.

Since the seamless knitting technologies are computerized there is great potential for small production runs with a wider range of variety. These machines could potentially create custom or made-to-measure garments. This also means that the quality of each piece created repeatedly has the ability to remain consistent. (Tait, 2008; Kanakaraj & Ramachandran, 2010)

Seamless knitting is gaining popularity and has the potential to hold 50% of the knitwear industry's sales within the next ten years with sufficient training facilities.(Madhumathi, Ramakrishnan & Sankaran, 2012)It is also projected to continue its growth and potentially be one of the largest 'next generation' knitting technologies. (Rao, 2012) Experts are certain complete garment knitting is unlikely to be a passing fad and is truly the next step in knitwear production. (Millington, 2001)

## DEMAND OF KNIT PRODUCTS

As we have seen thus far, complete garment knitting is a very important innovation for the textile industry due to its production efficiencies through automation. This method of production has the potential to create specialized products, with minimal processing and a reduced labor requirement. Since this technology is still in its infancy, very little data exists to justify its implementation in production, especially in a reshoring production scheme.

However, a very important component to this justification is quantifying the demand for knitted apparel. If demand is increasing, then one could speculate that an investment in new technologies like complete garment knitting will not be wasted. Per capita disposable income is expected to rise in the United States, giving consumers the ability to spend on nonessential items like knit apparel. Demand for clothing is also anticipated to increase in the next few years. It is also mentioned that niche manufacturers will cater to customers who prefer their products to be manufactured in the U.S. and this domestic demand will increase with time. (Haider, 2015)

Mintel Reports has found that of consumers surveyed, 50% of men and 46% of women has bought sweaters within the last twelve months. (Ghosh, 2016; Smith, 2015) Sweaters contain the second largest portion of the products and services segmentation for NAICS 31519 products in the United States, accounting for 23.5%. This is an important note to consider when deciding on the type of products to create domestically. (Haider, 2015)

Import data already has confirmed that the knitting sector is leading, accounting for 82% of total garment imports in 2014. These import figures only continue to rise. (Smith, 2014) A simple logarithm forecast, based on clothing import data provided by the WTO is found in Figure 2.

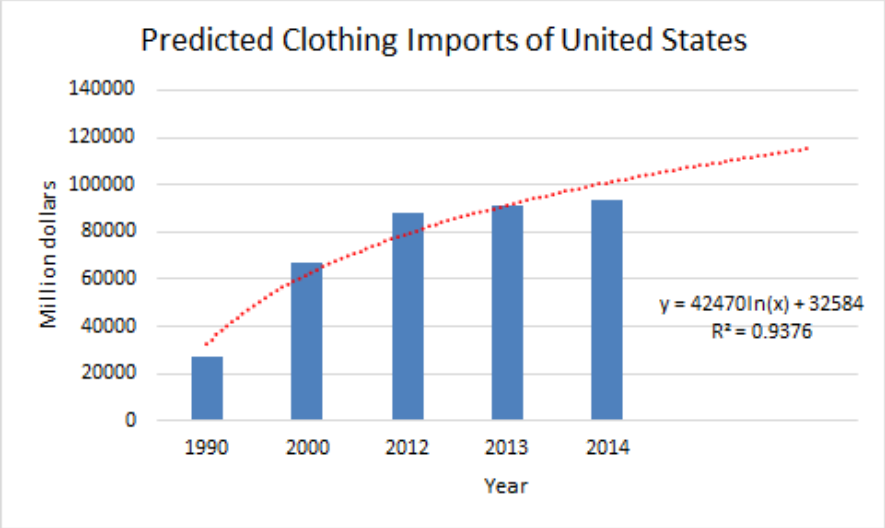



**Figure 2. Authors own, Adapted with WTO Clothing Import Data from 1990-2014**

Through the use of time-series analysis, financial data can reveal trends that might otherwise be over-inflated or under-inflated. Through import data gathered from the Office of Textiles and Apparel (OTEXA) of the U.S. Department of Commerce, a prediction of knit apparel demand and a justification for the investment of knitting technologies will be made.

## METHODOLOGY

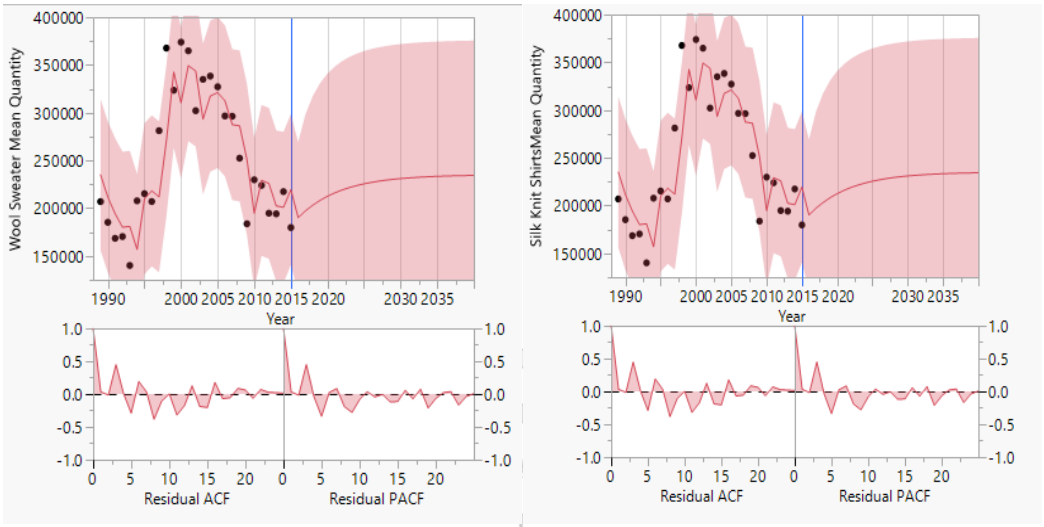
As we will be forecasting import trade of knitted apparel for the United States, it is important to consider the evidence that is present to project future demand. The time-series analysis method chosen for this study is a univariate Box-Jenkins, or ARIMA analysis. This type of forecasting allows for a combination or integrated (I) of time series and regression methods ("AR", meaning autoregressive and "MA" meaning moving average) and is appropriate given the historical data provided by OTEXA. ARIMA models require two steps: first, to analyze the data series and second, to choose the best fit forecasting model. Historical data is correlated to itself, creating new variables based on a series of lags. The benefit to using ARIMA over other modeling methods is the ability to create explanatory variables and identify the lagged demand historical values, aiding in projections. (Chase, 2013) ARIMA has been used for a wide variety of prediction studies related to trade, given a long-range set of data provided by governmental organizations. (Lu, 2015; Ozbek, Akalin, Tpouz & Sennaroglu, 2011; Seyoum, 2007; Muhammad, Bashir & Ahmad, 1992) In this study, these calculations will be made within JMP software, using an autoregressive order of 1, and a moving average order of 1.

The data for this analysis was found through the OTEXA website (Appendix A), which provides import and export trade data for specified groups within the textile supply chain. Categories relating to knit apparel were analyzed, including: cotton knit shirts, wool knit shirts, wool sweaters, man-made fiber knit shirts, man-made fiber sweaters, silk knit shirts, silk sweaters, silk blend sweaters and sweaters made of other non-cotton fibers. The difference between knit shirts and sweaters, depends on the gauge, or thickness of knit. What you might expect to be considered a "sweater" would in fact be considered a knit shirt according to OTEXA. For this reason, all categories relating to knits were analyzed. Each data set were divided by market- "WG" (womens and girls) and "MB" (mens and boys). The information was very lengthy in content, with product quantity and value in U.S. dollars provided for every month. To simplify the data, the mean was found for a given year, based on the twelve months of data displayed. Each product category was ultimately added together to

understand the total quantity of knit related products imported for the years of 1989 thru 2015. The hope during this analysis was to find any positive trend in U.S knit apparel imports to suggest a demand of products. (OTEXA, 2016)

## RESULTS

The graphs below show the product categories with a positive growth trend using ARIMA forecasting in JMP. Because these are the areas of the knit apparel product sector with a positive relationship, attention must be paid to why these specific areas are in larger demand than others. It can be speculated that investing in a technology which specializes in manufacturing either wool, "other non-cotton" fiber, and silk blend sweaters or silk knit shirts.




**Figures 3 & 4. Author's own, ARIMA Forecasting of Wool Sweaters Mean Quantity Imports to the U.S., and Silk Knit Shirts Mean Quantity Imports to the U.S.**

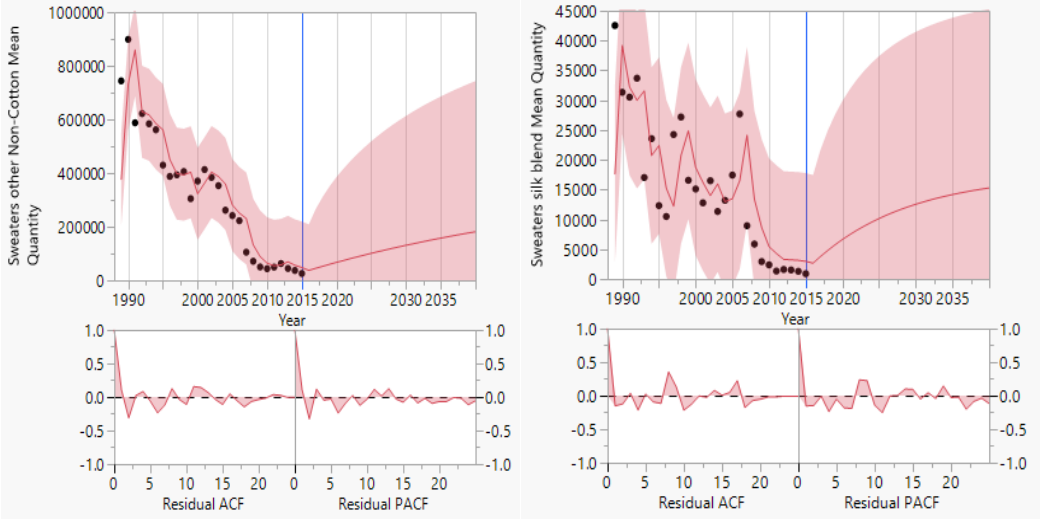



**Figure 5 & 6. Author's own, ARIMA Forecasting of "Other Non-Cotton" Sweater Imports to U.S. and Silk Blend Sweater Imports to the U.S.**

## CONCLUSION

This study demonstrated that the demand of knit apparel is sustainable in the United States, and asserts the growth is noteworthy as a potential area for reshoring within the textile industry. Based on the results of the ARIMA forecasting in this study, one can assert that an investment should be made towards an innovation which creates sweaters. We may assume with this information that consumer demand is driving this growth of imports for sweaters. Thanks to new innovations like complete garment knitting, the United States manufacturing sector may be able to grab their piece of this pie. Companies are constantly attempting to innovate and re-think their manufacturing efforts by moving from the lowest wage bidding country they can find. Will the textile industry recognize this demand growth as their opportunity to strike while the iron is hot? Or will they continue to scramble and find the cheapest labor possible and incur the costs and risks associated with outsourcing?

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## APPENDIX A

### Data from OTEXA website - Years 1989-2015

| Year | Knit Shirts Mean Quantity | Knit Shirts Mean Value | Wool Knit Shirts Mean | Wool Knit Shirts Mean | Wool Sweater Mean Quantity | Wool Sweater Mean Value | MMF Knit Shirt Mean Quantity | MMF Knit Shirt Mean Value | MMF Sweater Mean Quantity | MMF Sweater Mean Value |
|---|---|---|---|---|---|---|---|---|---|---|
| 1989 | 3091358 | 1.49E+08 | 50912.58 | 7896960 | 207005.5 | 44470526 | 3091358 | 1.49E+08 | 50912.58 | 10988318 |
| 1990 | 3286643 | 1.69E+08 | 44070.5 | 7882905 | 185345.4 | 39473426 | 3286643 | 1.69E+08 | 44070.5 | 11169547 |
| 1991 | 3254155 | 1.83E+08 | 52931.83 | 9081233 | 168627.3 | 34202222 | 3254155 | 1.84E+08 | 52931.83 | 12335388 |
| 1992 | 4273823 | 2.28E+08 | 66660.08 | 11989142 | 170451.6 | 37786996 | 4273823 | 2.28E+08 | 66660.08 | 16262965 |
| 1993 | 4417919 | 2.31E+08 | 52739.42 | 10300596 | 140197.2 | 34132069 | 4417919 | 2.32E+08 | 52739.42 | 14718515 |
| 1994 | 5501228 | 2.85E+08 | 66486.17 | 12285682 | 207886 | 43047621 | 5501228 | 2.85E+08 | 66486.17 | 17786910 |
| 1995 | 6955530 | 3.58E+08 | 90710.75 | 15620345 | 215355.8 | 44778528 | 6955530 | 3.59E+08 | 90710.75 | 22575876 |
| 1996 | 8106572 | 4.05E+08 | 88725.42 | 16892051 | 207133.8 | 45001594 | 8106572 | 4.05E+08 | 88725.42 | 24998623 |
| 1997 | 9963268 | 4.89E+08 | 113682.5 | 21776399 | 281318.3 | 59984153 | 9963268 | 4.89E+08 | 113682.5 | 31739667 |
| 1998 | 12969425 | 5.86E+08 | 130925.3 | 23851404 | 367778.8 | 72834604 | 12969425 | 5.86E+08 | 130925.3 | 36820829 |
| 1999 | 16160000 | 6.69E+08 | 155257.5 | 26851361 | 323678.7 | 70403843 | 16160000 | 6.7E+08 | 155257.5 | 43011361 |
| 2000 | 18910742 | 7.57E+08 | 173282.2 | 28754820 | 374033.5 | 84602789 | 18910742 | 7.57E+08 | 173282.2 | 47665562 |
| 2001 | 19521656 | 7.73E+08 | 196785.3 | 31824875 | 364931.9 | 77728348 | 19521656 | 7.74E+08 | 196785.3 | 51346531 |
| 2002 | 22096478 | 8.26E+08 | 165619.4 | 26658354 | 302210.1 | 62198980 | 22096478 | 8.26E+08 | 165619.4 | 48754832 |
| 2003 | 25753202 | 9.04E+08 | 148702.7 | 22906955 | 335103 | 65913781 | 25753202 | 9.04E+08 | 148702.7 | 48660157 |
| 2004 | 26851043 | 9.4E+08 | 150516.7 | 25366197 | 338459.8 | 78131821 | 26851043 | 9.4E+08 | 150516.7 | 52217240 |
| 2005 | 31015634 | 1.03E+09 | 171302.7 | 27274551 | 327288.9 | 82011447 | 31015634 | 1.03E+09 | 171302.7 | 58290185 |
| 2006 | 34132398 | 1.16E+09 | 145686.2 | 26580621 | 296701 | 75771325 | 34132398 | 1.16E+09 | 145686.2 | 60713019 |
| 2007 | 35395965 | 1.23E+09 | 158346.8 | 29793949 | 296403.1 | 77779465 | 35395965 | 1.23E+09 | 158346.8 | 65189914 |
| 2008 | 35053543 | 1.19E+09 | 157185.1 | 32505988 | 252467.3 | 72684512 | 35053543 | 1.19E+09 | 157185.1 | 67559531 |
| 2009 | 31921898 | 1.04E+09 | 142256.3 | 26631089 | 183799.1 | 48458116 | 31921898 | 1.04E+09 | 142256.3 | 58552986 |
| 2010 | 35765905 | 1.15E+09 | 186011 | 33400413 | 229893.8 | 58744604 | 35765905 | 1.15E+09 | 186011 | 69166318 |
| 2011 | 32650159 | 1.2E+09 | 182037.3 | 33255870 | 224049.1 | 65446106 | 32650159 | 1.2E+09 | 182037.3 | 65906028 |
| 2012 | 30709719 | 1.07E+09 | 180587.6 | 34726332 | 194918.5 | 59313055 | 30709719 | 1.07E+09 | 180587.6 | 65436051 |
| 2013 | 31344708 | 1.09E+09 | 175238.1 | 33361072 | 194260.1 | 60272152 | 31344708 | 1.09E+09 | 175238.1 | 64705779 |
| 2014 | 30558432 | 1.06E+09 | 174162.6 | 35394759 | 217493.3 | 70947310 | 30558432 | 1.06E+09 | 174162.6 | 65953191 |
| 2015 | 30836038 | 1.03E+09 | 151525.7 | 31253589 | 179854.7 | 60359434 | 30836038 | 1.03E+09 | 151525.7 | 62089627 |

| Silk Knit Shirts Mean Quantity | Silk Knit Shirts Mean Value | Silk Sweaters Mean Quantity | Silk Sweaters Mean Value | All Knits Mean Quantity | All Knits Mean Value | Sweaters silk blend Mean Quantity | Sweaters Silk Blend Mean Value | Sweaters other Non-Cotton Mean | Sweaters other non-cottonMean Value |
|---|---|---|---|---|---|---|---|---|---|
| 207005.5 | 44521438 | 3091358 | 149017060 | 9789909.167 | 554307405 | 42553.75 | 5707116.8 | 744154.67 | 71485129 |
| 185345.4 | 39517497 | 3286643 | 169117750 | 10318759.58 | 604840588 | 31350.083 | 4704195.8 | 898974.08 | 65727215 |
| 168627.3 | 34255154 | 3254155 | 183671858 | 10205582.58 | 640383688 | 30538.833 | 4621530.4 | 898974.08 | 67589292 |
| 170451.6 | 37853656 | 4273823 | 227929505 | 13295693.33 | 787169918 | 33708.083 | 4359046.7 | 622225.92 | 81818344 |
| 140197.2 | 34184809 | 4417919 | 231694355 | 13639630.42 | 787998461 | 17047.583 | 2585185.3 | 584262.58 | 72445702 |
| 207886 | 43114107 | 5501228 | 285038724 | 17052427.08 | 970726835 | 23575.167 | 3531771 | 561933.33 | 69237942 |
| 215355.8 | 44869239 | 6955530 | 358864818 | 21478724.42 | 1203792375 | 12336.917 | 1934351.6 | 430055.5 | 50631929 |
| 207133.8 | 45090319 | 8106572 | 405083787 | 24911432.83 | 1346612546 | 10514.833 | 1360977.1 | 387894.5 | 42523780 |
| 281318.3 | 60097836 | 9963268 | 489089694 | 30679804.75 | 1640023181 | 24265.75 | 2669009.2 | 393989.17 | 43143050 |
| 367778.8 | 72965530 | 12969425 | 586463109 | 39905683.67 | 1964758356 | 27197.667 | 3136148.7 | 406064.67 | 43387890 |
| 323678.7 | 70559100 | 16160000 | 669898917 | 49437872.08 | 2219551379 | 16586.583 | 2145375.7 | 305212.75 | 30956495 |
| 374033.5 | 84776071 | 18910742 | 757323280 | 57826857.58 | 2516646980 | 15121.667 | 2165592.3 | 370632 | 35110748 |
| 364931.9 | 77925134 | 19521656 | 774180206 | 59688402.5 | 2560270711 | 12800.5 | 1893860.9 | 413701.83 | 38426643 |
| 302210.1 | 62364599 | 22096478 | 826644045 | 67225091.5 | 2679002270 | 16521.333 | 2275900.7 | 384122.25 | 33693356 |
| 335103 | 66062484 | 25753202 | 904670666 | 78227217.33 | 2916550066 | 11360.333 | 1515657.8 | 353599.58 | 29979155 |
| 338459.8 | 78282338 | 26851043 | 940530944 | 81531081.33 | 3054575049 | 13228.25 | 1537317.7 | 262103.42 | 20713139 |
| 327288.9 | 82182750 | 31015634 | 1.033E+09 | 94044084.67 | 3346323205 | 17461.083 | 2144701.2 | 241929.83 | 18473467 |
| 296701 | 75917011 | 34132398 | 1.158E+09 | 103281968.3 | 3712289193 | 27711.75 | 3213874.8 | 222838.33 | 17996140 |
| 296403.1 | 77937812 | 35395965 | 1.227E+09 | 107097393.2 | 3929518416 | 8959.4167 | 1469799.8 | 105379.67 | 10238875 |
| 252467.3 | 72841697 | 35053543 | 1.187E+09 | 105979933.1 | 3805340045 | 5887.8333 | 986724.92 | 71658.417 | 7261000.3 |
| 183799.1 | 48600373 | 31921898 | 1.041E+09 | 96417803.42 | 3305863984 | 2945.8333 | 460185.33 | 50515.417 | 4953189 |
| 229893.8 | 58930615 | 35765905 | 1.155E+09 | 108129523.9 | 3684965367 | 2392.25 | 600141.08 | 43795.917 | 4687589.8 |
| 224049.1 | 65628143 | 32650159 | 1.196E+09 | 98762648.42 | 3817536081 | 1359.5833 | 386198.83 | 49953.25 | 6172711.1 |
| 194918.5 | 59493643 | 30709719 | 1.067E+09 | 92880168.92 | 3420868051 | 1626.9167 | 310648.67 | 63336.083 | 7296726.7 |
| 194260.1 | 60447390 | 31344708 | 1.09E+09 | 94773119.08 | 3486946913 | 1540 | 340991.33 | 44897.417 | 5460390.3 |
| 217493.3 | 71121473 | 30558432 | 1.058E+09 | 92458606.67 | 3416088568 | 1319.3333 | 320283.67 | 37293.917 | 4518951.9 |
| 179854.7 | 60510960 | 30836038 | 1.029E+09 | 93170874.67 | 3300349748 | 913.25 | 304232.58 | 26061.833 | 3814226.3 |