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# Mapping Food Flow Networks and the Food Supply Chain, Part 3

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The United States is a key nation for the global food security and availability. It is a major producer, consumer, and trade power in grain commodities, such as soybean, corn, sorghum, and wheat.

In 2012 a severe drought hit the U.S. Corn Belt, a highly productive region for grain. The 2012 drought led to a 55% variation in corn yield across the region. Illinois, Iowa, Indiana, Minnesota, and Nebraska were the main states impacted by the drought. Domestic trade and transport were a key way that supply chains reorganized to adapt to production losses from drought.

This makes it important to evaluate how domestic agricultural and food flows reorganized in response to the 2012 Corn Belt drought. Here, we examine county scale grain (SCTG 02) flow changes within the United States through time, especially during the 2012 drought for the Corn Belt.

**Drought Impacts to National Mass Flux**

We use the empirical data on Freight Analysis Framework (FAF) spatial scale food flows within the U.S. for the years 2007, 2012, and 2017 (for more detail please refer to our first article in this series, *farmdoc daily* July 6 2023). We also estimate county spatial scale food flows within the U.S. for the year 2007, 2012, and 2017 by the improved version of Food Flow Model (for more detail please refer to our second article in this series, *farmdoc daily* July 13 2023). Then, we examine the impacts of 2012 Corn Belt drought on national SCTG 02 (cereal grain) commodity flows across spatial scales (please refer to our original study for more details).

The drought effect is clear in our study since the total mass flux of grain in 2012 is the lowest among all study years both at FAF and county spatial scales (see Figure 1). The Corn Belt remains a top region for grain outflow in 2012, despite the drought. However, the mass of grain outflows is lower in 2012 due to decreased grain production during the drought. Grain outflows from the Corn Belt decreased by $3.29E{+}10^{11}$ kg (53.18%) from 2007 to 2012, while inflows also decreased ($2.84E{+}10^{11}$ kg; 53.67%).

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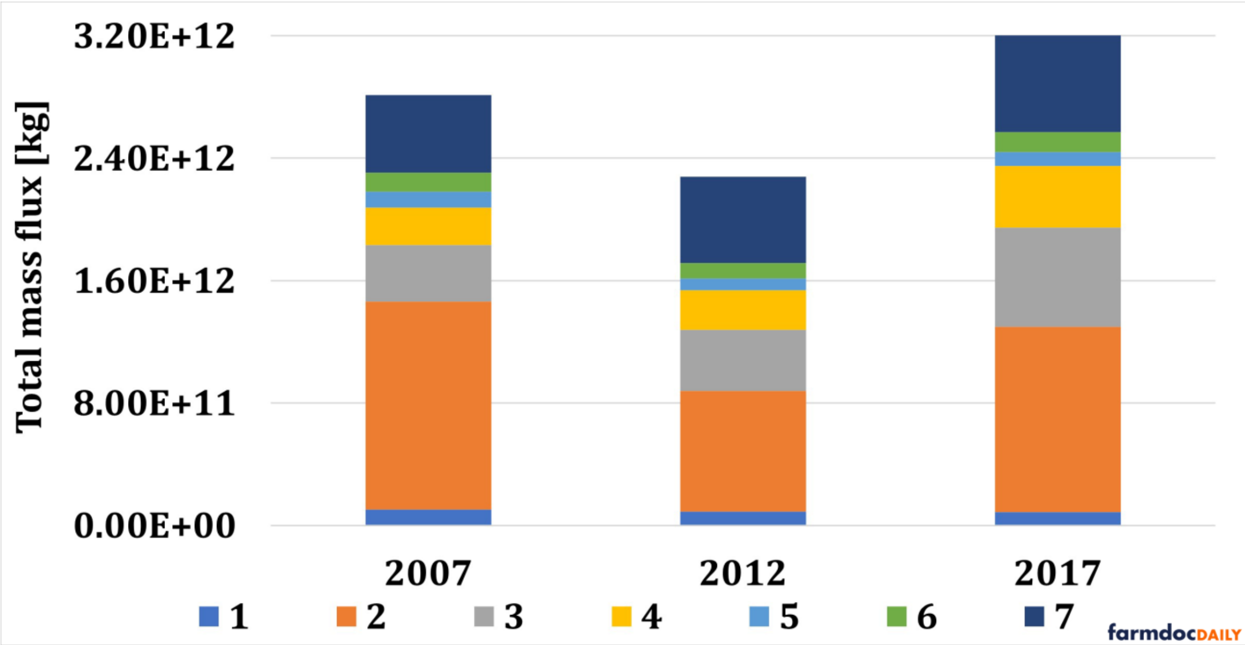
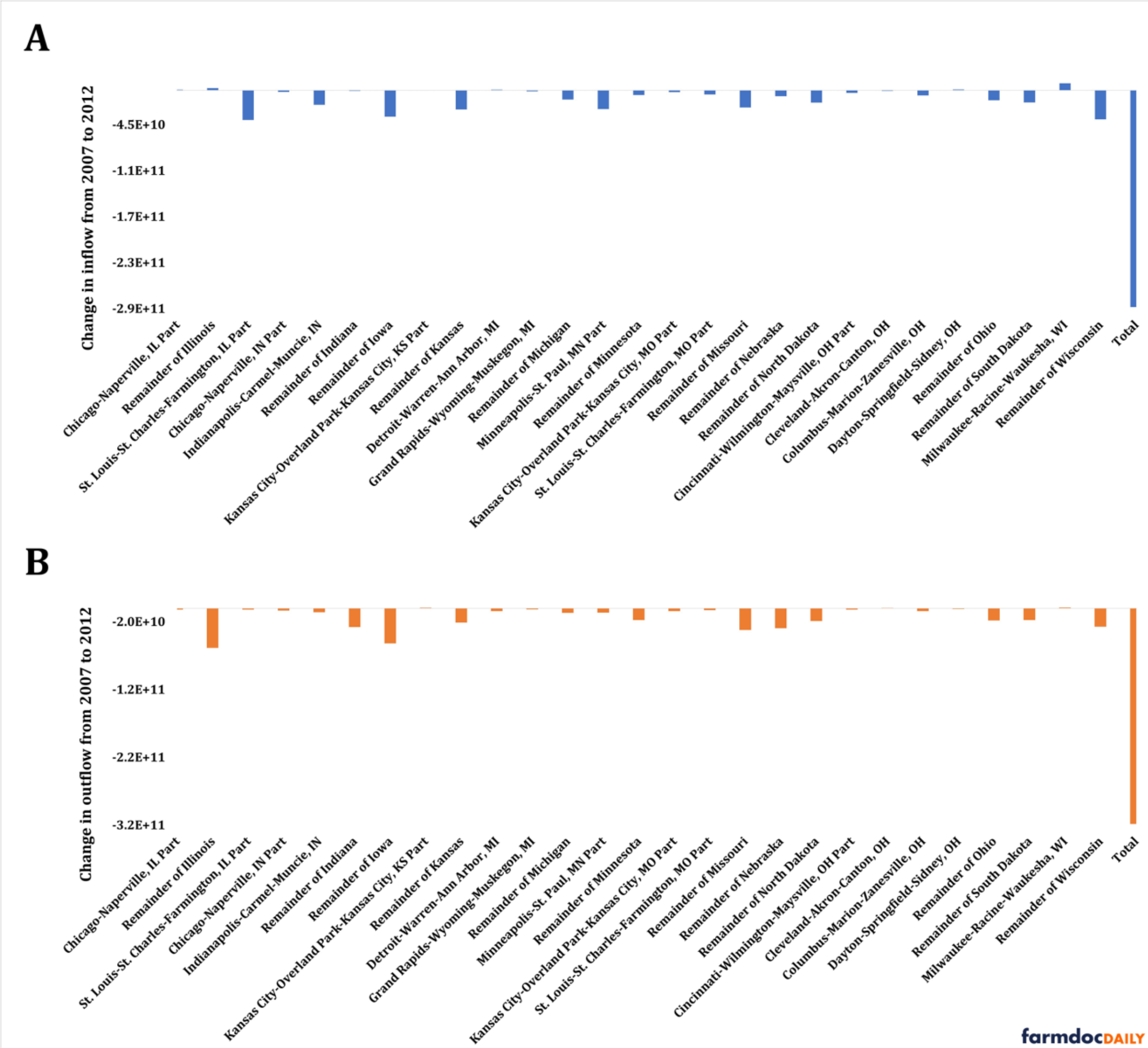
**Figure 1. Total Mass Flux of Food Flow Networks over Time by SCTG Commodity.** Note the mass flux increases from 2007 to 2017, but is lowest in 2012, which was a drought year in the Corn Belt and Central Valley. The total mass flux of county and FAF networks are perfectly matched due to the mass balance constraint of the Food Flow Model.




**Drought Impacts to Mass Flux Across Locations**

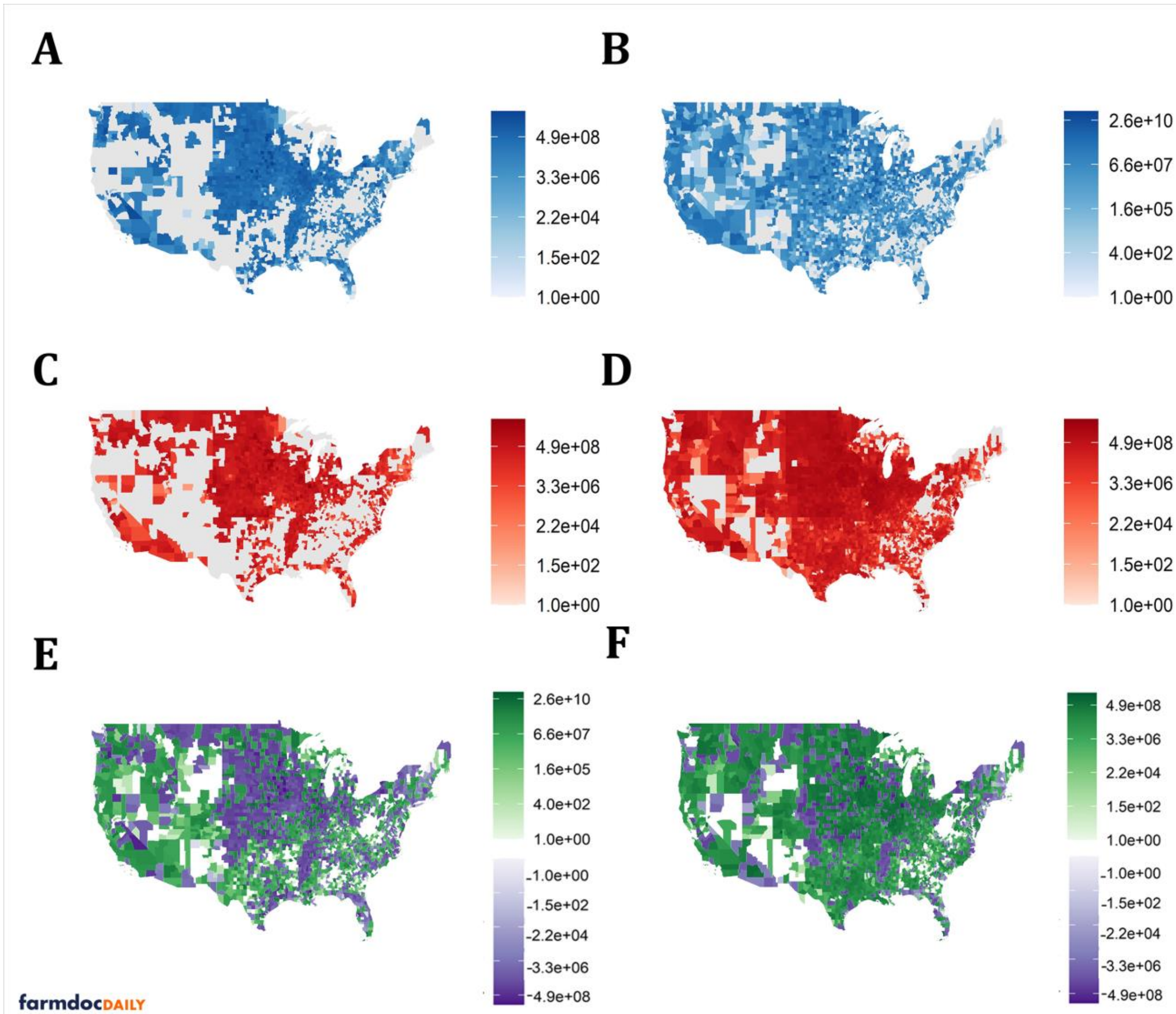
Across FAF zones, the mass of grain outflow is 15.28%–68.05% lower in 2012 than in 2007. As in Figure 2, grain inflows also decrease from 2007 to 2012. Corn Belt grain outflows and inflows rebound in 2017 following the drought: outflows increase by 11.67%–129.65% and inflows increase by 30.72%–114.22% across FAF zones from 2012 to 2017. This indicates the importance of grain production and processing within the regional agricultural economy.

**Figure 2. Change in Mass Inflows and Outflows [kg] for SCTG 02 Commodities for FAF Zones in the Corn-Belt from 2007 to 2012.** A) Change in inflows from 2007 to 2012, B) Change in outflows from 2007 to 2012. Both inflows and outflows are generally higher in 2007 than 2012.



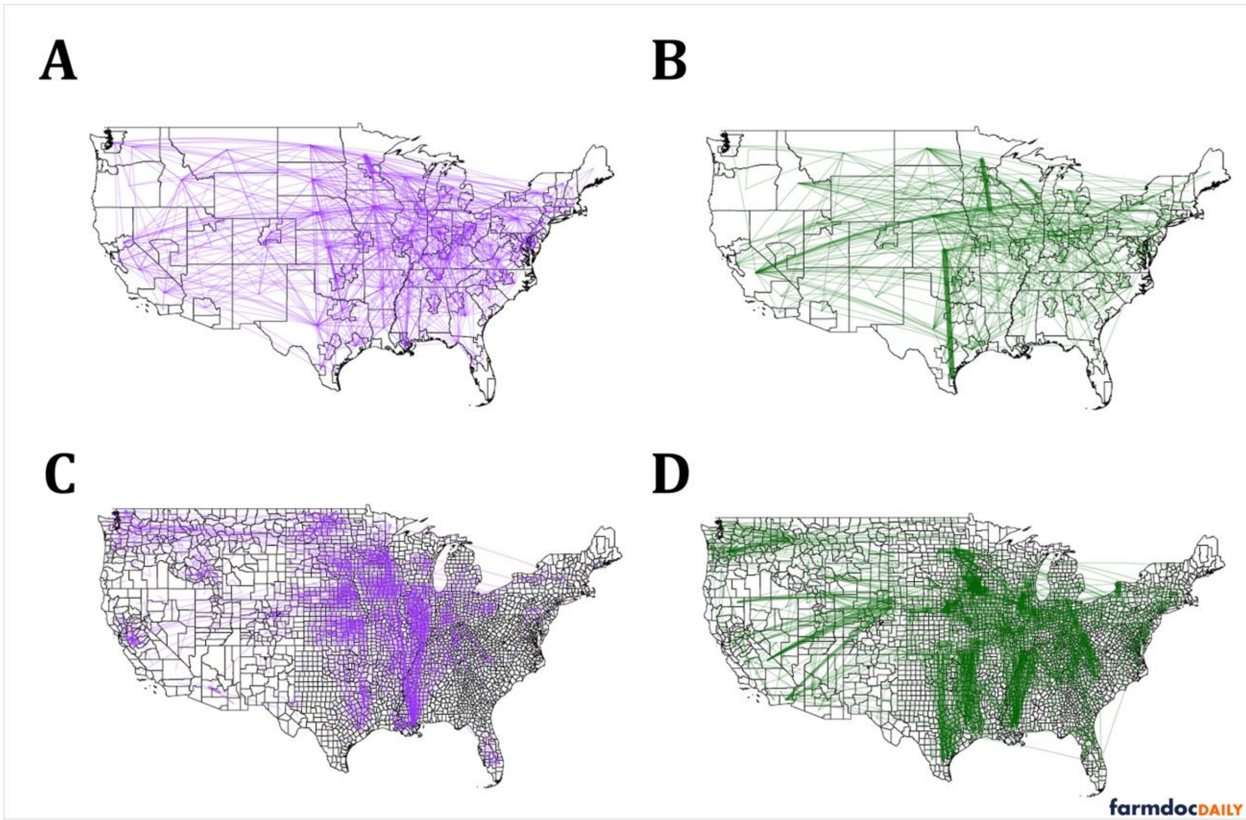

Similar observations are illustrated in Figure 3 at county spatial scale. In 2012, which is the drought year, counties in Corn Belt and Central Valley generally have more densely accumulated SCTG 02 inflows at higher amounts. In 2017, we observe an overall decrease in the total SCTG 02 inflows in the same region, with some exceptions. These exceptions (in 2017 still relatively high SCTG 02 inflows in Corn Belt and Central Valley counties) are due to the increase in the self-loop flows within the region. For the outflows, the observation is the complete opposite. In 2017, Corn Belt and Central Valley counties have more densely accumulated SCTG 02 outflows with higher amounts when compared with 2012. The overall trend is captured in Figure 3(E) and in Figure 3(F) where SCTG 02 inflows generally decrease from 2012 to 2017 whereas outflows generally increase from 2012 to 2017 in the Corn Belt and Central Valley counties. In the same illustration we observe that SCTG 02 inflows and outflows increase in California, Washington, and East Coast from 2012 to 2017.

**Figure 3. SCTG 02 (Cereal Grains) Flows [kg] from 2012 to 2017 per County Based on Our Estimations**. (A) 2012 SCTG 02 inflows, (B) 2017 SCTG 02 inflows, (C) 2012 SCTG 02 outflows, (D) 2017 SCTG 02 outflows. Darker blue shades represent higher inflows, darker red shades represent higher outflows. (E) Change in SCTG 02 inflows from 2012 to 2017, (F) Change in SCTG 02 outflows from 2012 to 2017. Darker purple shades represent a higher decrease, darker green shades represent a higher increase in the flows from 2012 to 2017.




Link-level changes in grain flows are mapped in Figure 4. The largest mass decreases in grain links are concentrated in the Corn Belt FAF zones (see Figure 4(A)), which indicates more internal movement in a non-drought year. From 2007 to 2012, mass increases in cereal grain flows to/from the Corn Belt are connected with the rest of the nation, such as California, Texas, and Mississippi FAF zones (Figure 4(B)). Similar to FAF-level networks, decreases in mass flux from 2007 to 2012 are mainly concentrated in the Corn Belt, while the increases are heterogeneously distributed around the nation in the county-level networks (see Figure 4(C) and Figure 4(D)).

**Figure 4. Change in Grain Flows [kg] during the 2012 Drought**. The top 2000 links by mass are shown in county-level. The top 1000 links by mass are shown in FAF-level. (A) Mass reductions from 2007 to 2012 in FAF-level. (B) Mass increases from 2007 to 2012 at FAF-level. (C) Mass reductions from 2007 to 2012 at county-level. (D) Mass increases from 2007 to 2012 at county-level.

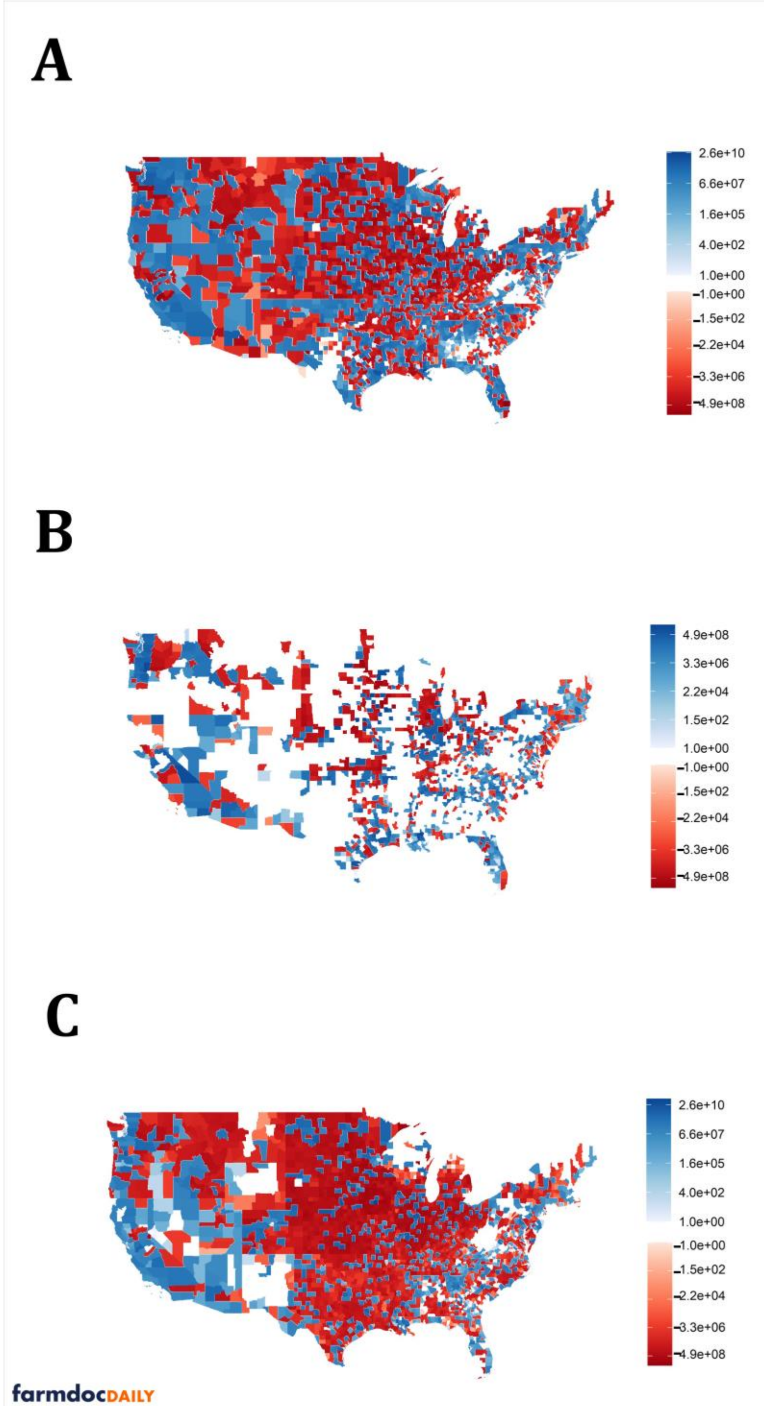



**Implications**

We evaluate the impacts of 2012 Corn Belt drought on food flows between the U.S. counties. Our study clearly shows that in 2012, SCTG 02 food flows to/from Corn Belt and Central Valley counties (and FAF zones) are heavily impacted, as their SCTG 02 supplies across the U.S. was relatively less (see Figure 5). Both in 2007 and 2017, outflows of cereal grains from Corn Belt counties are higher than 2012.

Our finer spatial scale analysis of the effects of 2012 Corn Belt drought on food flows within the U.S. could be useful for researchers and policy makers to evaluate opportunities to adapt supply chains to shocks.

**Figure 5. The County Spatial Scale Net Flows (= Inflows - Outflows) Of SCTG 02 (Cereal Grains) Through Time.** (A) 2007, (B) 2012, (C) 2017. Darker red shades represent higher outflows than inflows, darker blue shades represent higher inflows than outflows.

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