Supporting materials

Text S1: Decomposition of direct carbon emissions

The decomposition of direct carbon emissions:

$$C_p = POP \times \frac{GDP}{POP} \times \frac{GDP_{clothing}}{GDP} \times \left(\sum_i \frac{gdp_i}{GDP_{clothing}} \times \frac{energy_i}{gdp_i} \times \frac{C_i}{energy_i} \right) ,$$

(S1)

Where C_p and C_i represents direction carbon emissions of the textile and apparel industry and the corresponding sector i, respectively. GDP, $GDP_{clothing}$ and gdp_i represents the total GDP, the GDP of textile and apparel industry and the GDP of the corresponding sector respectively. $energy_i$ denotes the energy consumption of sector i. Eq. (S1) can be further formulated as:

$$C_p = POP \times EO \times IS \times \left(\sum_i TS_i \times EI_i \times EC_i \right) , \quad \text{(S2)}$$

Where POP represents population effect, EO represents represent economic output, IS represents industry structure effect, TS_i, EI_i and EC_i represents textile and apparel industry structure effect, energy intensity effect and energy carbon intensity effect respectively.

According to Eq. (S2), C_p can be decomposed into the following items:

$$\Delta C_p = C_p^t - C_p^{t-1} = \Delta C_{POP} + \Delta C_{EO} + \Delta C_{IS} + \Delta C_{TS} + \Delta C_{EI} + \Delta C_{EC} , \quad \text{(S3)}$$

$$\Delta C_{POP} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{POP^t}{POP^{t-1}} \right) , \quad \text{(S4)}$$

$$\Delta C_{EO}=\sum_i\left(\frac{C_i^t-C_i^{t-1}}{\ln\left(C_i^t\right)-\ln\left(C_i^{t-1}\right)}\right)\times\ln\left(\frac{EO^t}{EO^{t-1}}\right) \quad , \tag{S5}$$

$$\Delta C_{IS}=\sum_i\left(\frac{C_i^t-C_i^{t-1}}{\ln\left(C_i^t\right)-\ln\left(C_i^{t-1}\right)}\right)\times\ln\left(\frac{IS^t}{IS^{t-1}}\right) \quad , \tag{S6}$$

$$\Delta C_{TS}=\sum_i\left(\frac{C_i^t-C_i^{t-1}}{\ln\left(C_i^t\right)-\ln\left(C_i^{t-1}\right)}\right)\times\ln\left(\frac{TS_i^t}{TS_i^{t-1}}\right) \quad , \tag{S7}$$

$$\Delta C_{EI}=\sum_i\left(\frac{C_i^t-C_i^{t-1}}{\ln\left(C_i^t\right)-\ln\left(C_i^{t-1}\right)}\right)\times\ln\left(\frac{EI_i^t}{EI_i^{t-1}}\right) \quad , \tag{S8}$$

$$\Delta C_{EI}=\sum_i\left(\frac{C_i^t-C_i^{t-1}}{\ln\left(C_i^t\right)-\ln\left(C_i^{t-1}\right)}\right)\times\ln\left(\frac{EI_i^t}{EI_i^{t-1}}\right) \quad , \tag{S9}$$

Text S2: Decomposition of household consumption and export carbon emissions

Referring to Text S1, this study decomposed carbon emissions embodied in household consumption and export as follows:

$$\begin{aligned} C_{household} &= \sum_i POP\times\frac{pop_i}{POP}\times con_i\times\frac{con_i^{clothing}}{con_i}\times\left(\sum_j O_{ij}\times f_j\right) \\ &= POP\times\sum_i\left(PS_i\times CON_i\times CS_i\times\sum_j CF_{ij}\right) \end{aligned} \quad , \tag{S10}$$

$$\begin{aligned} C_{\exp ort} &= \sum_i E\times\frac{E_i}{E}\times\left(\sum_j O_{ij}\times f_j\right) \\ &= E\times\sum_i\left(ES_i\times\sum_j CF_{ij}\right) \end{aligned} \quad , \tag{S11}$$

The decomposition of carbon emissions embodied in household consumption:

$$\Delta C_{household}=C_{household}^t-C_{household}^{t-1}=\Delta C_{POP}+\Delta C_{PS}+\Delta C_{CON}+\Delta C_{CS}+\Delta C_{CF} \quad , \tag{S12}$$

$$\Delta C_{POP}=\sum_i\left(\frac{C_i^t-C_i^{t-1}}{\ln\left(C_i^t\right)-\ln\left(C_i^{t-1}\right)}\right)\times\ln\left(\frac{POP^t}{POP^{t-1}}\right) \quad , \tag{S13}$$

$$\Delta C_{PS} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{PS_i^t}{PS_i^{t-1}} \right) \quad , \tag{S14}$$

$$\Delta C_{CON} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{CON_i^t}{CON_i^{t-1}} \right) \quad , \tag{S15}$$

$$\Delta C_{CS} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{CS_i^t}{CS_i^{t-1}} \right) \quad , \tag{S16}$$

$$\Delta C_{CF} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{\sum_j CF_{ij}^t}{\sum_j CF_{ij}^{t-1}} \right) \quad , \tag{S17}$$

The decomposition of carbon emissions embodied in exports:

$$\Delta C_{export} = C_{export}^t - C_{export}^{t-1} = \Delta C_E + \Delta C_{ES} + \Delta C_{CF} \quad , \tag{S18}$$

$$\Delta C_E = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{E^t}{E^{t-1}} \right) \quad , \tag{S19}$$

$$\Delta C_{ES} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{ES_i^t}{ES_i^{t-1}} \right) \quad , \tag{S20}$$

$$\Delta C_{CF} = \sum_i \left(\frac{C_i^t - C_i^{t-1}}{\ln\left(C_i^t\right) - \ln\left(C_i^{t-1}\right)} \right) \times \ln\left(\frac{\sum_j CF_{ij}^t}{\sum_j CF_{ij}^{t-1}} \right) \quad , \tag{S21}$$

Text S3: Parameterized settings for 5 scenarios

This study designed five scenarios to explore the potential of carbon abatement of textile industry:

(1) Business as usual scenario (BAU): Scenario maintains 2018 levels of energy-saving technology, renewable energy penetration, and recycling rates.

(2) Energy-saving technology promotion scenario (S1): Referring to the Energy Saving

Technology Guide for the Textile Industry energy consumption rate for the spinning, weaving and wetting process is 22%, 20%, and 58%, respectively. In addition, we referred to results from Lawrence Berkeley National Laboratory Hasanbeigi (2010) and Huang et al. (2017), for the three main production processes of energy consumption in the textile industry (spinning, weaving and wet process), energy-saving technologies can reduce energy consumption by 42.5%, 55% and 51.5% at most. We then averaged the energy saving ratio according to the energy consumption rate, and the overall energy saving ratio of textile industry is 50.22%. Moreover, according to the National Key Energy-saving Technology Extension Directory (2013) and China National Textile and Apparel Council (2015), the extension rate of energy saving technologies in the textile industry in China is approximately 37% in 2018, assuming that the application rate will rise to 45%, 65%, and 90% in 2020, 2025, and 2030, respectively.

(3) Renewable energy promotion scenario (S2): According to Renewable Energy Development Plan for the 14th Five-Year Plan, the total consumption responsibility weight of renewable energy power is expected to reach 28.8% in 2020 and 33% in 2025. According to the long-term goal of renewable energy development, we set this proportion at 50% by 2035 (Abhyankar et al., 2022). This study assumes that the carbon footprint of renewable energy is 0. Therefore, we use the following formula to roughly calculate the change in carbon intensity caused by this:

$$C_1 = C_0 * \frac{(1-P_1)}{(1-P_0)} \quad , \tag{S22}$$

Where P_0 is the penetration rate of renewable energy in 2018, C_0 is the carbon footprints of sectors in 2018.

(4) Recycling and reusing clothes scenario (S3): A government report on waste recycling projects that China's recycling rate for waste textiles will increase to 25% by 2025 and 30% by 2030. Based on this goal, we set a scenario where the recycling rate increases linearly, which is in line with the trends observed in the waste management dataset compiled by the OECD. After that, based on clothing demand data from 2000 to 2030 (forecast data after 2018) and annual recycling rates, we calculated how much clothing (in terms of value) needs to be produced each year to meet clothing demand (detailed data can be found in **Table S6** and **Table S7**).

(5) Scenario that combines S2 and S3 (S4): This scenario models the joint implementation of "renewable energy + recycling and reuse" to assess the carbon reduction potential from the synergy of multiple strategies targeted at key stages of the industrial chain.

Table S1 The concordance matrix that matches consumption with sectors.

Name	Code	Household consumption	Textile exports	Clothing exports
Agricultural, Forestry and Fishery products and Services	s1	0	1	0
Extraction Products	s2	0	0	0
Food and Tobacco	s3	0	0	0
Textiles, Clothing, Shoes, Hats and Leather Down Products	s4	1	1	1
Woodworking, Furniture, Papermaking and printing, and Educational and sporting goods	s5	0	0	0
Petroleum, Coking, Processed nuclear fuel and Chemical products	s6	0	1	0
Non-metallic mineral products	s7	0	0	0
Metal smelting, Processing and Products	s8	0	0	0
Mechanical equipment, Transportation equipment, Electrical and electronic and Other equipment	s9	1	1	1
Other manufactured goods and Repair services	s10	0	0	0
Production and supply of electricity, heat, gas and water	s11	0	0	0
Construction	s12	0	0	0
Transportation, storage, postal and Telecommunication services	s13	0	1	1
Others	s14	1	1	1

Table S2 The distribution matrix of household consumption.

Year	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14
2000	0.100	0.081	0.054	0.279	0.054	0.276	0.025	0.162	0.653	0.015	0.084	0.018	0.115	0.870
2001	0.085	0.087	0.037	0.247	0.073	0.264	0.018	0.169	0.720	0.017	0.076	0.035	0.130	0.830
2002	0.072	0.076	0.037	0.206	0.070	0.216	0.021	0.176	0.657	0.020	0.062	0.018	0.116	0.847
2003	0.077	0.083	0.049	0.201	0.079	0.227	0.042	0.186	0.731	0.011	0.053	0.007	0.136	0.832
2004	0.103	0.115	0.064	0.201	0.083	0.265	0.054	0.239	0.812	0.014	0.104	0.028	0.141	0.787
2005	0.082	0.138	0.040	0.201	0.081	0.229	0.110	0.260	0.836	0.020	0.101	0.022	0.144	0.774
2006	0.092	0.127	0.066	0.215	0.069	0.278	0.039	0.245	0.946	0.020	0.105	0.012	0.138	0.746
2007	0.080	0.136	0.059	0.216	0.076	0.306	0.028	0.299	0.892	0.028	0.117	0.007	0.102	0.753
2008	0.103	0.154	0.076	0.208	0.075	0.314	0.029	0.287	0.869	0.026	0.102	0.001	0.113	0.760
2009	0.103	0.123	0.088	0.204	0.082	0.284	0.030	0.277	0.834	0.025	0.096	0.006	0.115	0.783
2010	0.082	0.157	0.062	0.185	0.073	0.298	0.033	0.279	0.886	0.024	0.108	0.007	0.109	0.763
2011	0.076	0.145	0.063	0.173	0.062	0.283	0.020	0.269	0.813	0.020	0.085	0.021	0.097	0.812
2012	0.073	0.130	0.063	0.166	0.053	0.272	0.027	0.264	0.808	0.017	0.081	0.011	0.102	0.876
2013	0.078	0.123	0.072	0.173	0.055	0.265	0.025	0.234	0.801	0.017	0.080	0.008	0.111	0.936
2014	0.078	0.108	0.074	0.172	0.058	0.259	0.024	0.221	0.813	0.015	0.074	0.006	0.109	0.928
2015	0.087	0.083	0.080	0.169	0.055	0.248	0.026	0.206	0.751	0.014	0.076	0.010	0.111	0.986
2016	0.068	0.068	0.079	0.166	0.065	0.215	0.025	0.176	0.749	0.013	0.059	0.007	0.121	0.991
2017	0.062	0.075	0.059	0.141	0.047	0.198	0.020	0.160	0.705	0.013	0.059	0.005	0.122	1.008
2018	0.059	0.073	0.055	0.127	0.046	0.184	0.020	0.157	0.665	0.014	0.058	0.006	0.132	1.039

Table S3 The distribution matrix of textile exports.

Year	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14
2000	0.246	0.089	0.054	0.228	0.048	0.334	0.022	0.139	0.542	0.015	0.083	0.016	0.151	0.719
2001	0.244	0.092	0.038	0.200	0.065	0.328	0.016	0.143	0.592	0.016	0.074	0.031	0.159	0.684
2002	0.211	0.083	0.041	0.166	0.063	0.273	0.019	0.152	0.548	0.018	0.061	0.016	0.167	0.705
2003	0.199	0.088	0.053	0.166	0.072	0.275	0.038	0.163	0.624	0.011	0.052	0.006	0.177	0.711
2004	0.202	0.120	0.065	0.168	0.076	0.316	0.049	0.212	0.701	0.013	0.102	0.026	0.187	0.679
2005	0.168	0.144	0.044	0.171	0.075	0.272	0.102	0.233	0.730	0.019	0.099	0.020	0.199	0.678
2006	0.169	0.136	0.071	0.185	0.064	0.339	0.036	0.220	0.830	0.019	0.103	0.011	0.181	0.659
2007	0.151	0.145	0.064	0.185	0.070	0.376	0.026	0.267	0.778	0.026	0.117	0.006	0.157	0.660
2008	0.169	0.164	0.081	0.181	0.071	0.386	0.028	0.259	0.764	0.024	0.102	0.001	0.156	0.677
2009	0.170	0.128	0.094	0.181	0.078	0.342	0.028	0.251	0.741	0.023	0.096	0.006	0.154	0.703
2010	0.138	0.167	0.067	0.163	0.069	0.369	0.032	0.256	0.793	0.022	0.109	0.006	0.154	0.688
2011	0.149	0.155	0.069	0.148	0.059	0.357	0.019	0.241	0.708	0.019	0.086	0.020	0.150	0.720
2012	0.147	0.141	0.070	0.142	0.050	0.345	0.025	0.235	0.697	0.015	0.083	0.010	0.176	0.770
2013	0.145	0.135	0.080	0.149	0.052	0.345	0.023	0.209	0.696	0.016	0.083	0.007	0.188	0.829
2014	0.144	0.120	0.082	0.148	0.055	0.334	0.023	0.199	0.708	0.014	0.077	0.006	0.192	0.821
2015	0.139	0.089	0.087	0.148	0.053	0.316	0.025	0.188	0.668	0.013	0.080	0.010	0.191	0.887
2016	0.131	0.075	0.084	0.142	0.063	0.287	0.023	0.158	0.653	0.013	0.062	0.007	0.216	0.879
2017	0.117	0.081	0.062	0.119	0.044	0.259	0.019	0.141	0.607	0.012	0.061	0.004	0.223	0.882
2018	0.111	0.082	0.057	0.108	0.043	0.247	0.018	0.140	0.575	0.013	0.060	0.005	0.228	0.910

Table S4 The distribution matrix of clothing exports.

Year	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14
2000	0.097	0.081	0.052	0.267	0.053	0.278	0.024	0.158	0.635	0.016	0.083	0.018	0.167	0.836
2001	0.083	0.087	0.036	0.237	0.072	0.268	0.018	0.165	0.699	0.017	0.077	0.035	0.176	0.801
2002	0.070	0.076	0.035	0.194	0.069	0.219	0.021	0.171	0.634	0.020	0.061	0.018	0.183	0.808
2003	0.075	0.082	0.048	0.192	0.078	0.225	0.041	0.182	0.712	0.011	0.052	0.007	0.193	0.802
2004	0.100	0.114	0.062	0.191	0.082	0.268	0.052	0.233	0.786	0.014	0.104	0.028	0.201	0.756
2005	0.080	0.138	0.039	0.190	0.080	0.233	0.108	0.252	0.804	0.020	0.100	0.022	0.212	0.740
2006	0.090	0.128	0.065	0.205	0.067	0.287	0.038	0.237	0.913	0.020	0.105	0.012	0.190	0.720
2007	0.078	0.135	0.058	0.205	0.074	0.310	0.027	0.288	0.854	0.028	0.116	0.007	0.167	0.720
2008	0.101	0.156	0.075	0.199	0.074	0.321	0.029	0.278	0.837	0.025	0.101	0.001	0.163	0.734
2009	0.102	0.122	0.087	0.197	0.081	0.284	0.030	0.270	0.809	0.025	0.096	0.006	0.161	0.762
2010	0.081	0.156	0.061	0.177	0.072	0.303	0.033	0.272	0.858	0.023	0.107	0.007	0.160	0.740
2011	0.076	0.145	0.062	0.164	0.061	0.290	0.020	0.260	0.780	0.020	0.085	0.021	0.159	0.783
2012	0.072	0.130	0.062	0.156	0.053	0.278	0.026	0.254	0.768	0.016	0.082	0.011	0.189	0.837
2013	0.077	0.123	0.071	0.162	0.054	0.271	0.024	0.225	0.763	0.017	0.081	0.008	0.200	0.895
2014	0.077	0.108	0.073	0.160	0.057	0.264	0.024	0.212	0.772	0.014	0.075	0.006	0.203	0.884
2015	0.086	0.082	0.078	0.158	0.055	0.250	0.025	0.199	0.718	0.013	0.077	0.010	0.200	0.941
2016	0.065	0.067	0.077	0.153	0.065	0.215	0.024	0.168	0.709	0.013	0.059	0.007	0.228	0.942
2017	0.059	0.073	0.057	0.128	0.046	0.197	0.019	0.150	0.657	0.013	0.059	0.005	0.236	0.944
2018	0.056	0.072	0.053	0.117	0.045	0.184	0.019	0.148	0.622	0.013	0.058	0.006	0.241	0.975

Table S5 Details of the scenario setup.

Scenario	BAU (2018)	2020	2025	2030	Information Source
S1 (promoting energy efficiency)	37%	45%	65%	90%	Huang et al. (2017)
S2 (promoting renewable energy penetration)	26.5%	28.8%	33%	50%(Abhyankar et al., 2022)	Renewable Energy Development Plan for the 14th Five-Year Plan (https://www.ndrc.gov.cn/xwdt/tzgg/202206/P020220601502009073293.pdf?eqid=9c2ef8cf000498470000000364603946, latest access: 2024.10.25)
S3 (enhancing recycling and reusing)	18%	20%	25%	30%	government report (https://www.gov.cn/xinwen/2022-04/14/content_5685154.htm, latest access: 2024.10.25)
S4	/	/	/	/	Combining S2 with S3

Table S6 Projected demand for textile and apparel from 2020 to 2035.

Year	Export (cloth)	Export (textile)	Household
2020	65362619.7	55464204.5	130643576.9
2021	63307093.9	57126393.2	133798193.7
2022	61316210.3	58838395.5	137028984.1
2023	59387936.1	60601704.3	140337787.6
2024	57520302.4	62417857.1	143726488.0
2025	55711402.0	64288437.6	147197014.4
2026	53959388.0	66215077.0	150751342.7
2027	52262471.4	68199455.1	154391496.5
2028	50618919.5	70243302.5	158119548.1
2029	49027054.0	72348401.2	161937620.0
2030	47485249.6	74516587.0	165847885.9
2031	45991931.9	76749750.4	169852572.0
2032	44545576.1	79049838.7	173953958.2
2033	43144705.4	81418857.7	178154379.5
2034	41787889.3	83858873.0	182456227.4
2035	40473742.3	86372012.4	186861950.8

Unit: 10,000 yuan

Table S7 Textile and apparel needed to be produced in S3 scenario.

Year	Export (cloth)	Export (textile)	Household
2020	63936163.8	54179981.7	127729136.3
2021	61197015.5	55195180.5	129376350.5
2022	58578538.4	56224809.2	131036992.3
2023	56069871.7	57272426.1	132715022.1
2024	53666827.9	58337763.8	134410491.6
2025	51365390.3	59421228.7	136123777.2
2026	49161402.9	60523269.9	137855370.3
2027	47050917.5	61644307.3	139605731.3
2028	45030130.8	62784778.0	141375330.9
2029	43095374.8	63945130.2	143164648.1
2030	41243118.0	65125821.5	144974169.3
2031	39469960.6	66327320.9	146804388.0
2032	37772630.7	67550107.7	148655804.5
2033	36147980.9	68794672.4	150528926.7
2034	34592984.2	70061517.0	152424269.7
2035	33104730.3	71351154.5	154342356.0

Figure S1: Carbon emission flows of China's textile industry in 2000

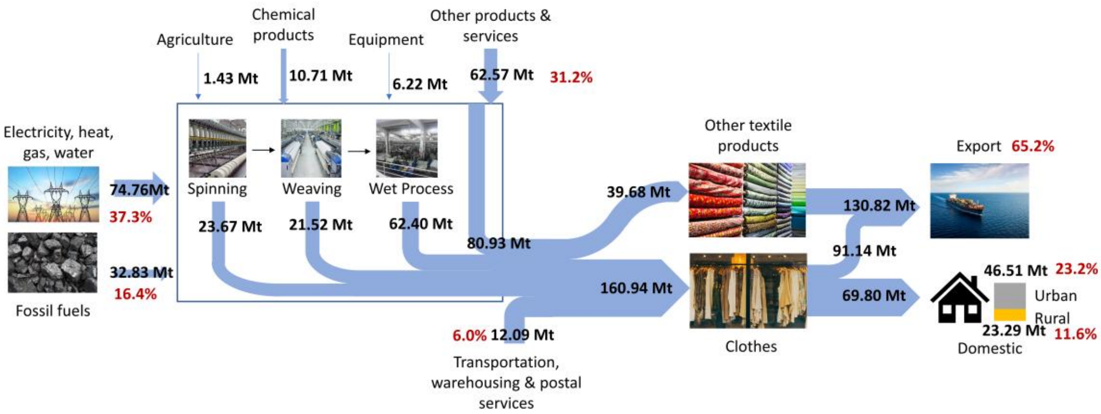

Fig. S1 Carbon emission flows of China's textile industry in 2000.

Figure S2: Carbon emissions of S3 when the recycled used textile and apparel can be used for 1 year, 2 years, 4 years and 6 years, respectively.

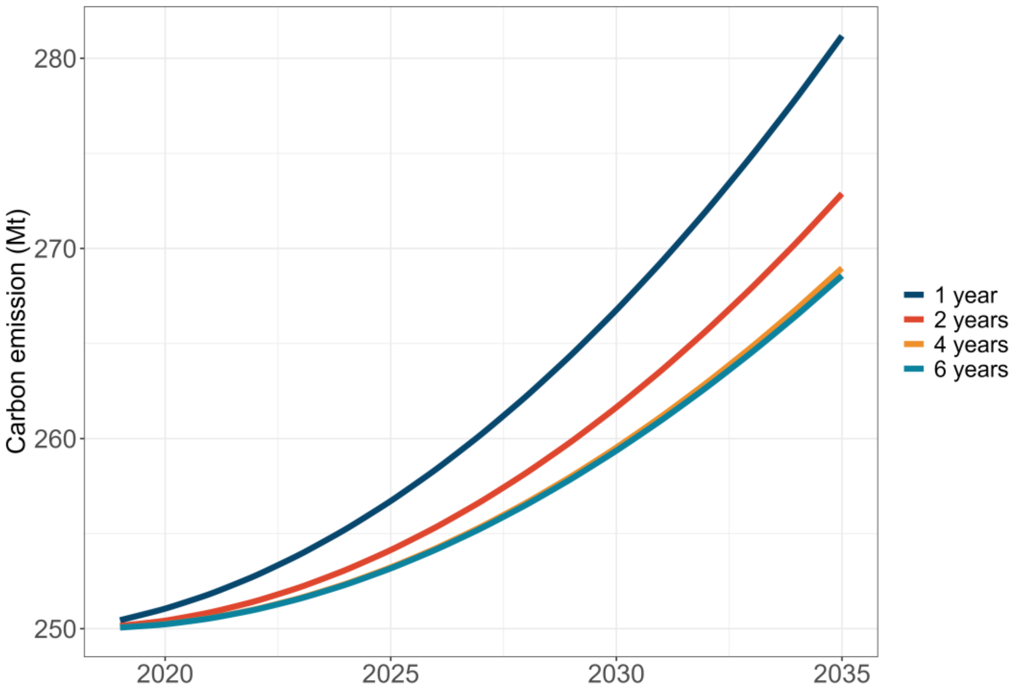

Fig. S2 Carbon emissions of S3 when the recycled used textile and apparel can be used for 1 year, 2 years, 4 years and 6 years, respectively.

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