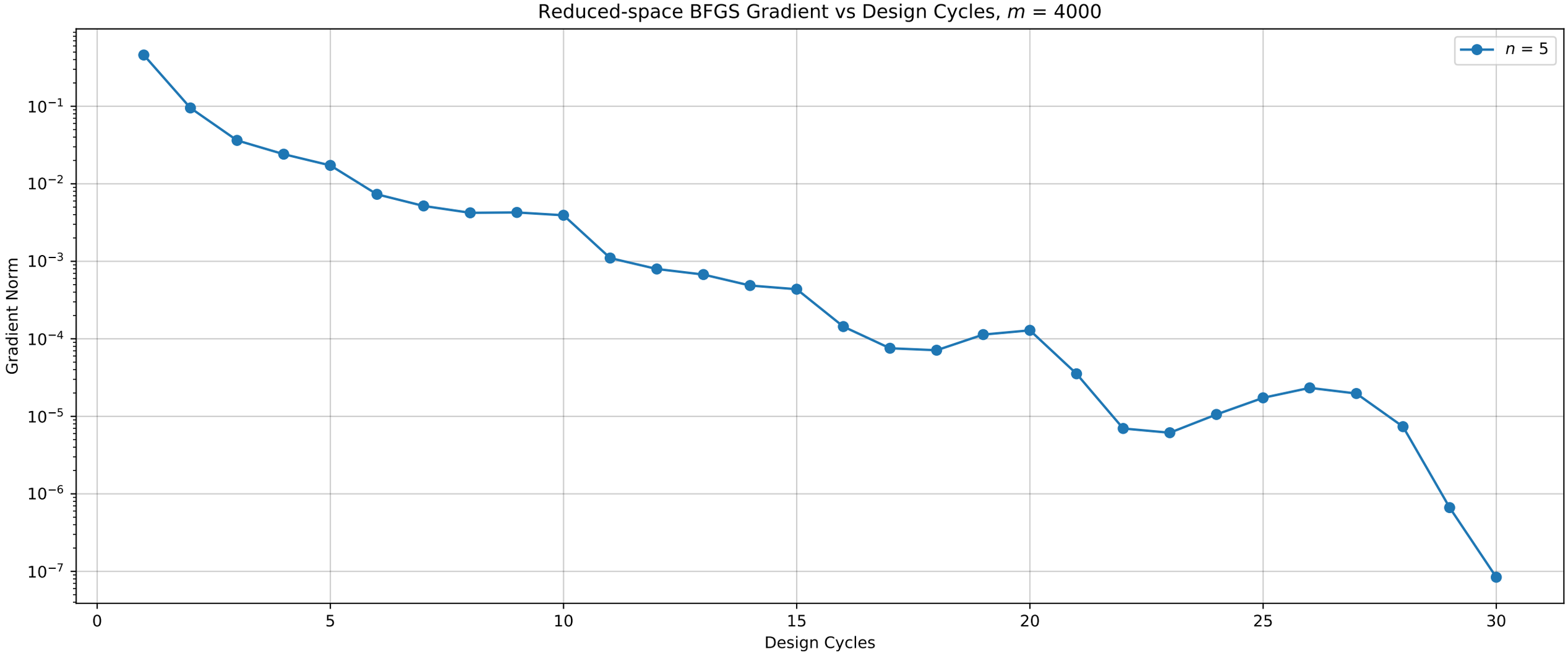
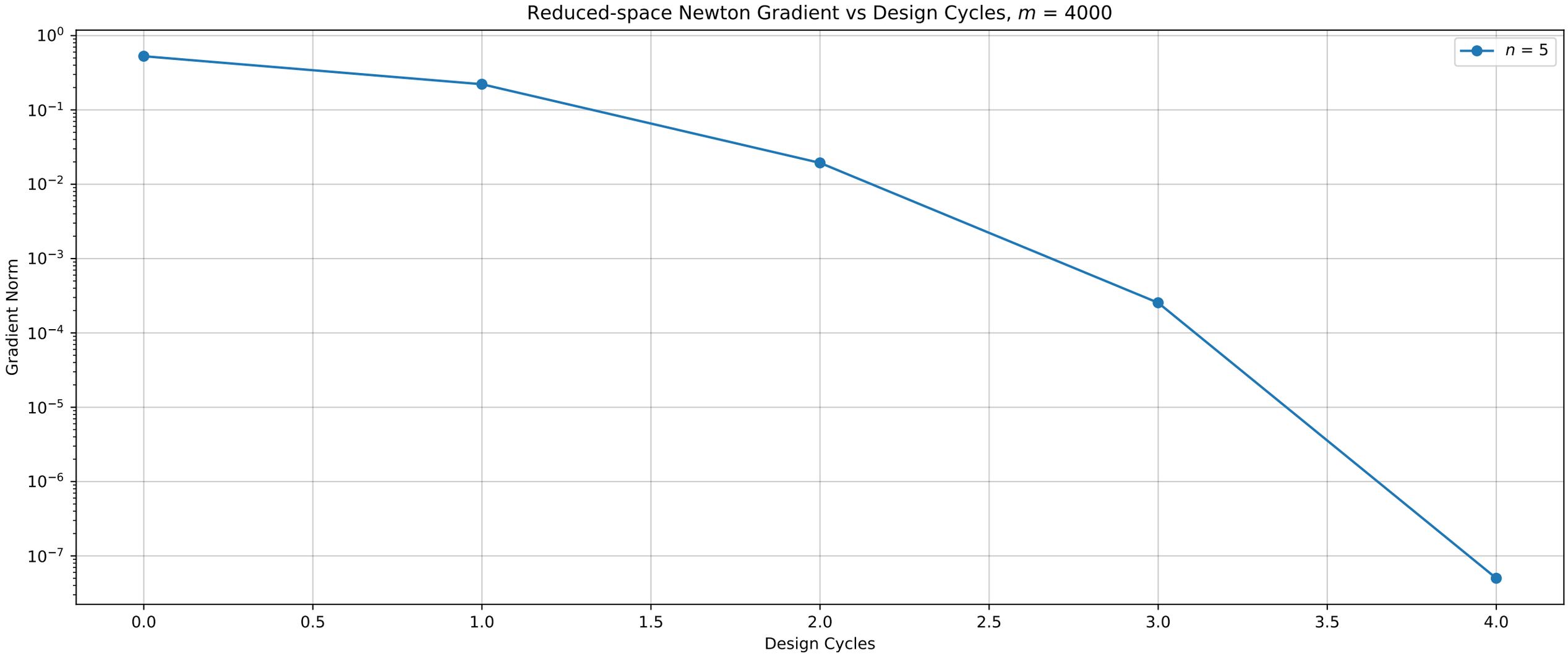
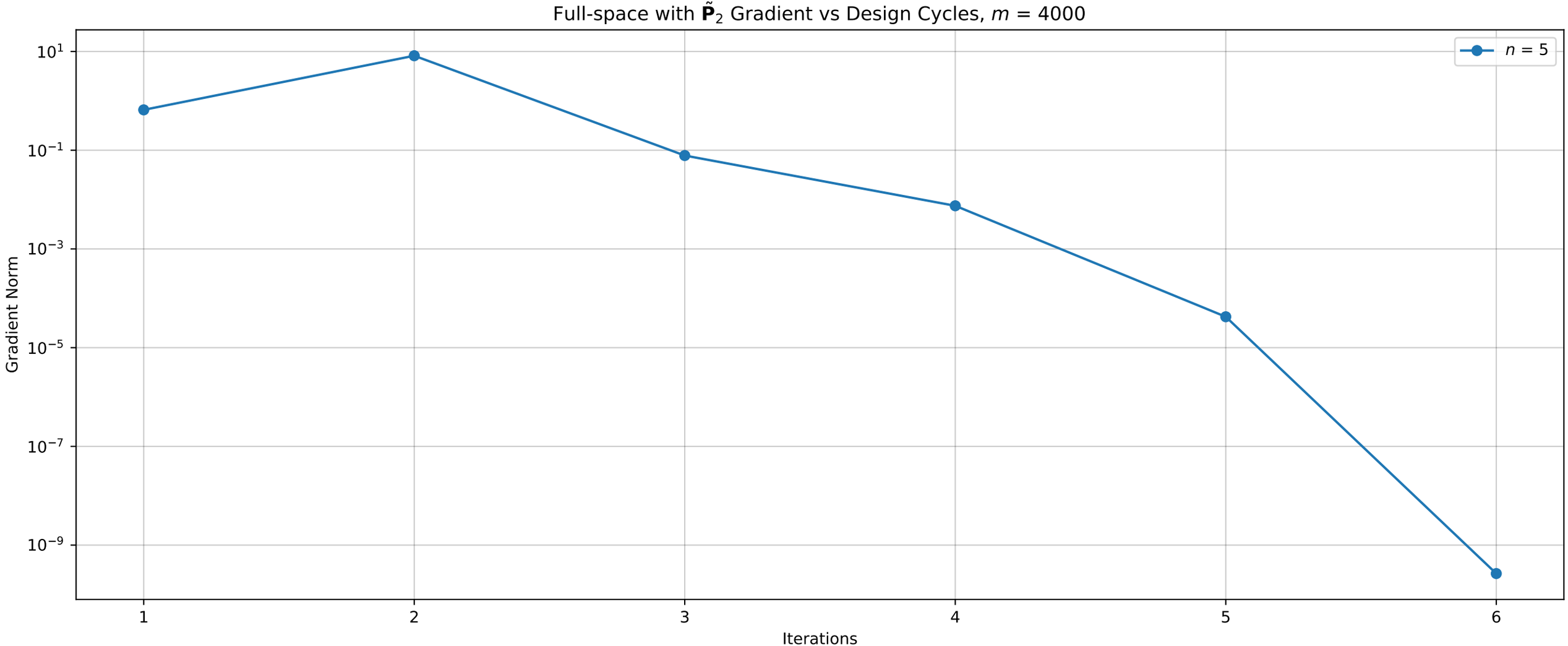
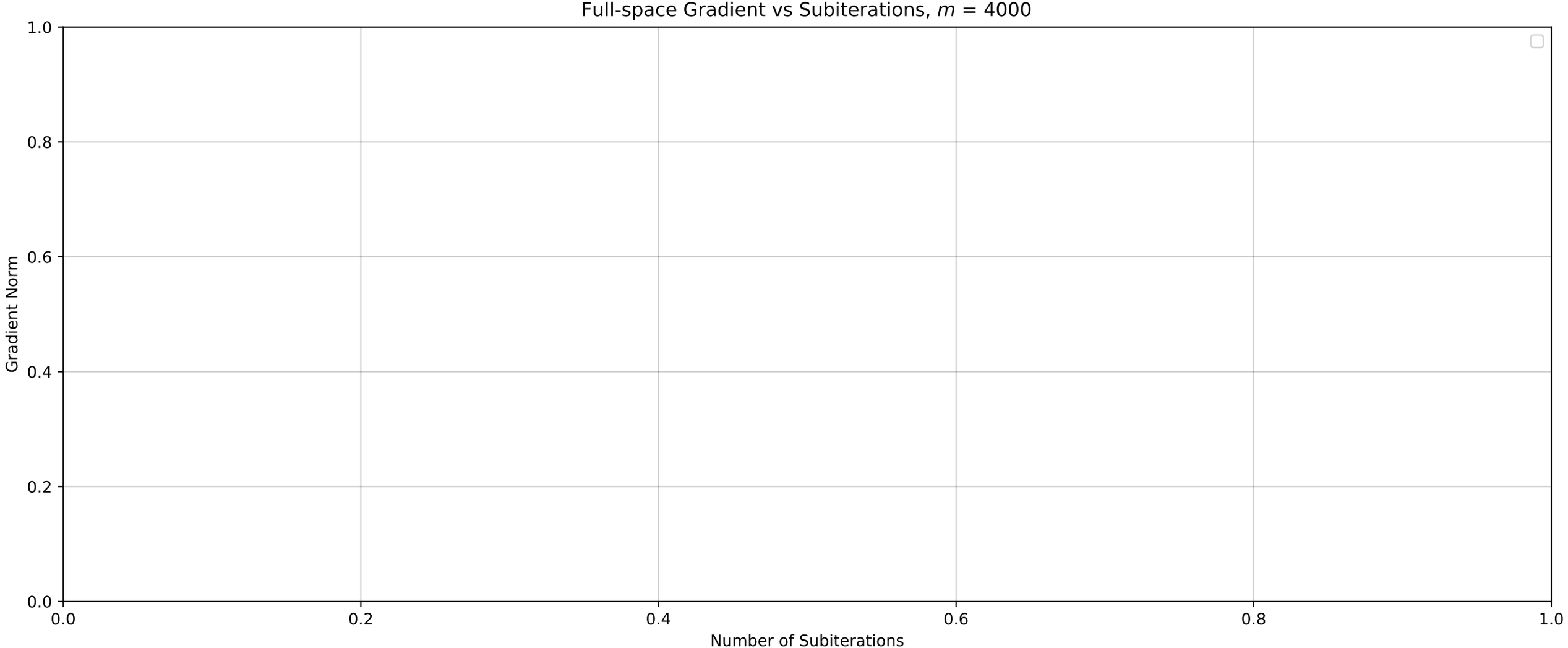
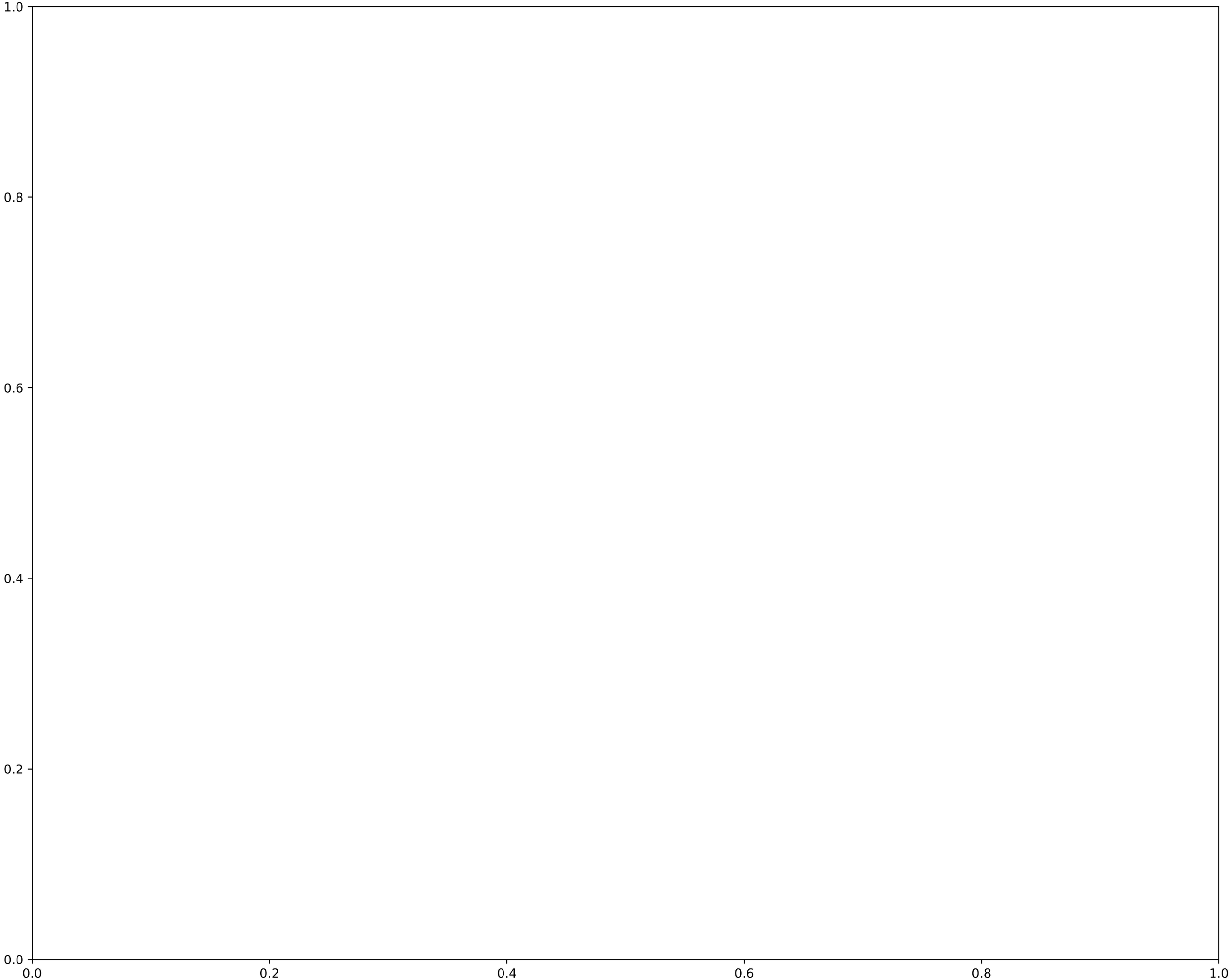

Reduced-space BFGS Gradient vs Design Cycles, m = 4000
n = 5
Gradient Norm
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
5
10
15
20
25
30
Design Cycles

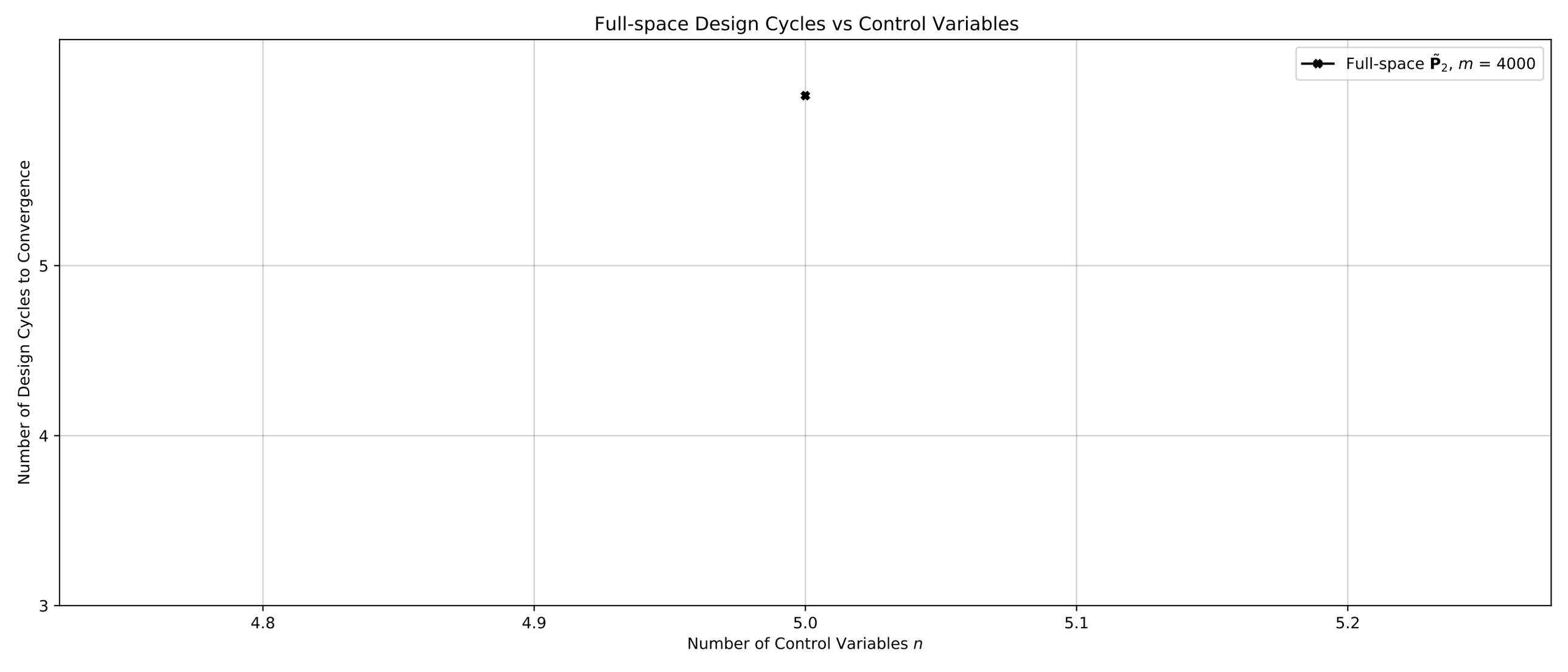

Reduced-space Newton Gradient vs Design Cycles, m = 4000
Gradient Norm
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Design Cycles
n = 5

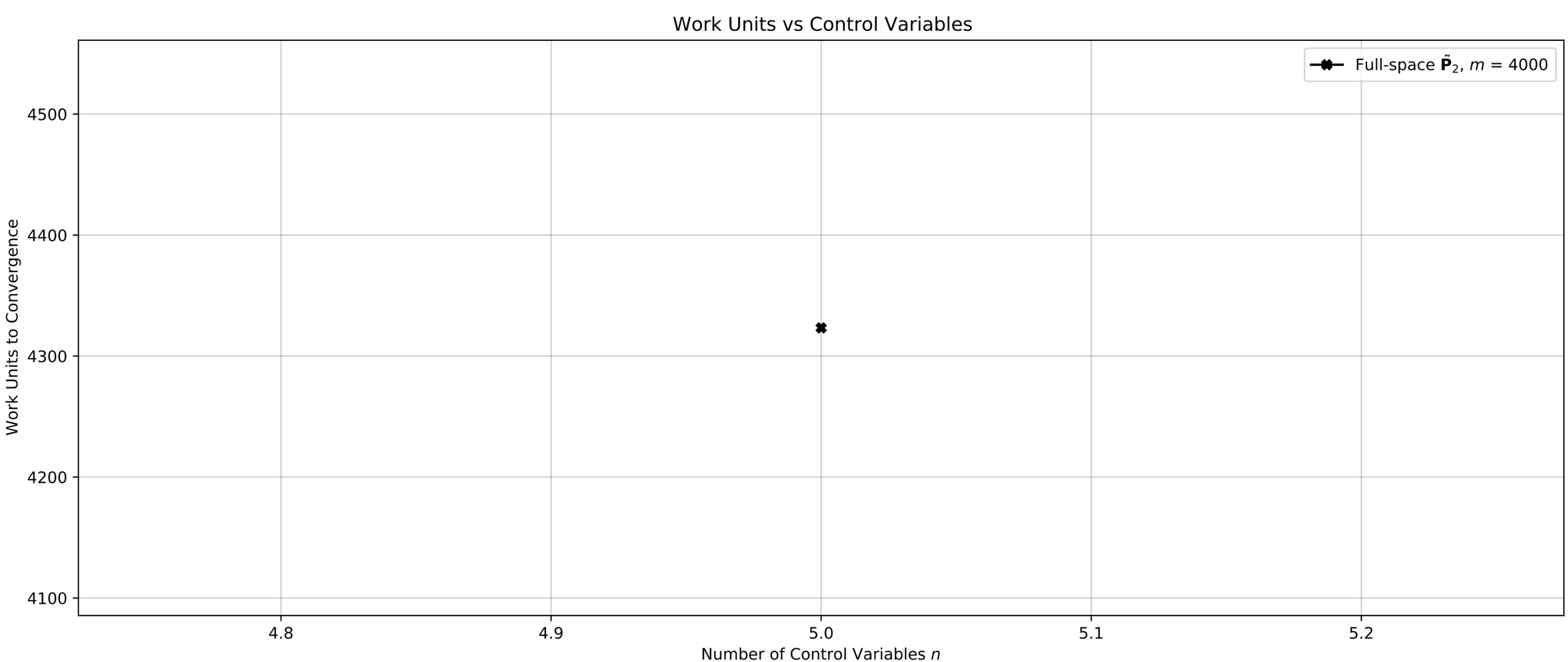

Full-space with $\tilde{\mathbf{P}}_2$ Gradient vs Design Cycles, m = 4000
n = 5
Gradient Norm
10^{1}
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
1
2
3
4
5
6
Iterations

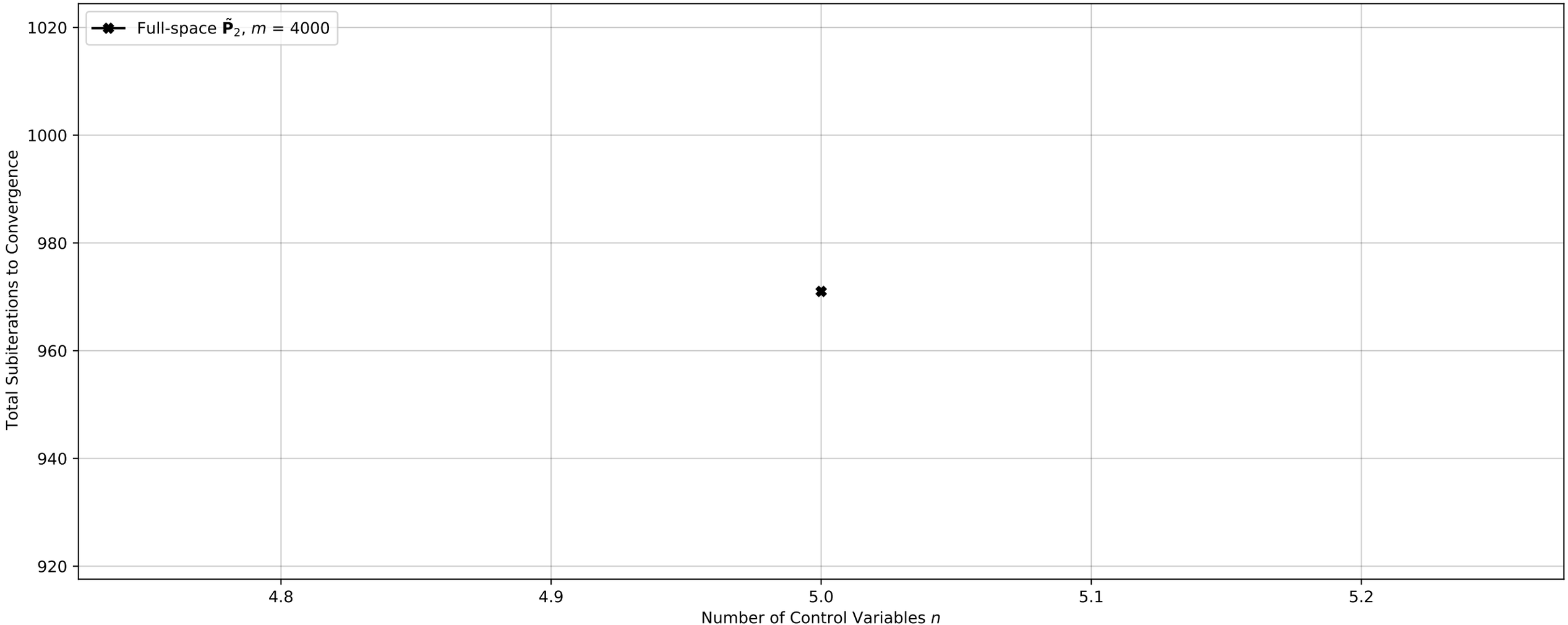

Full-space Gradient vs Subiterations, m = 4000
Gradient Norm
Number of Subiterations
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

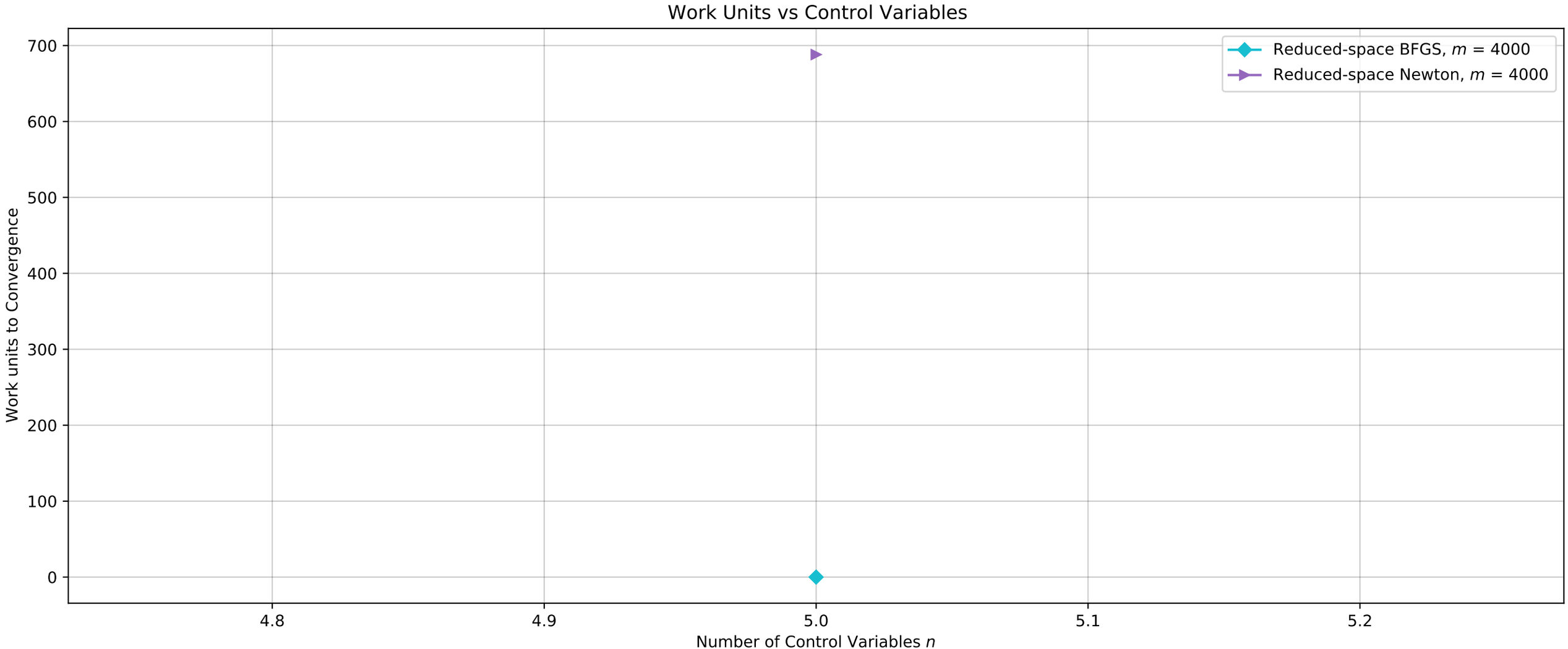
Full-space Gradient vs Subiterations

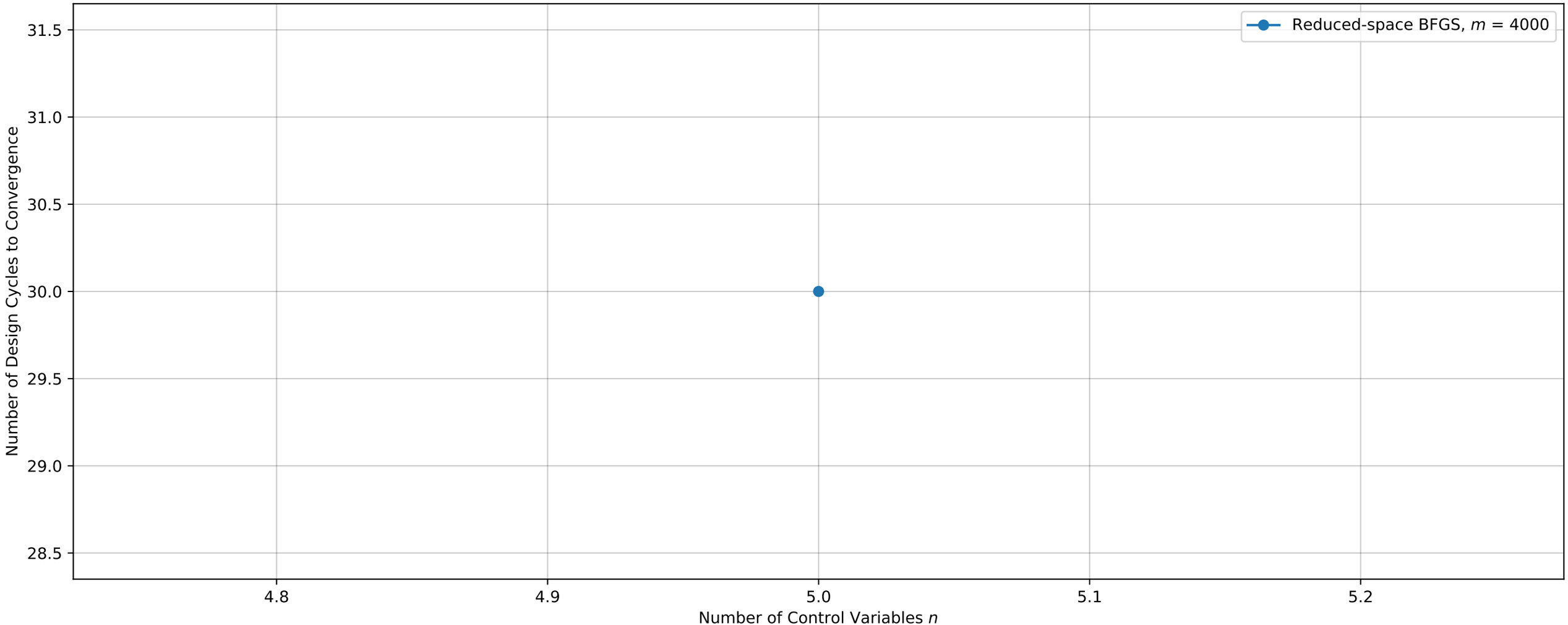


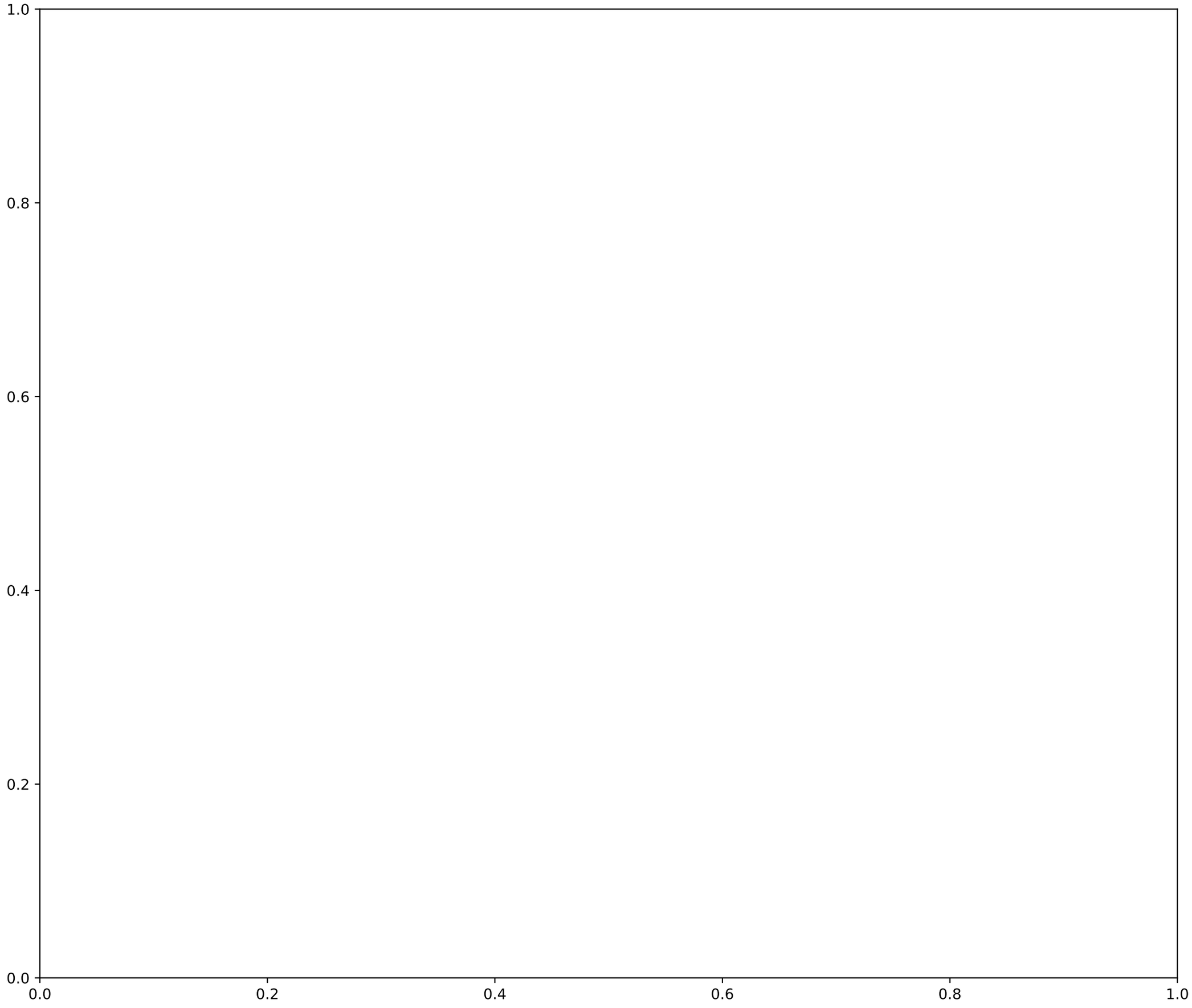

Full-space Design Cycles vs Control Variables
Full-space $\tilde{\mathbf{P}}_2$, m = 4000
Number of Design Cycles to Convergence
5
4
3
4.8
4.9
5.0
5.1
5.2
Number of Control Variables n

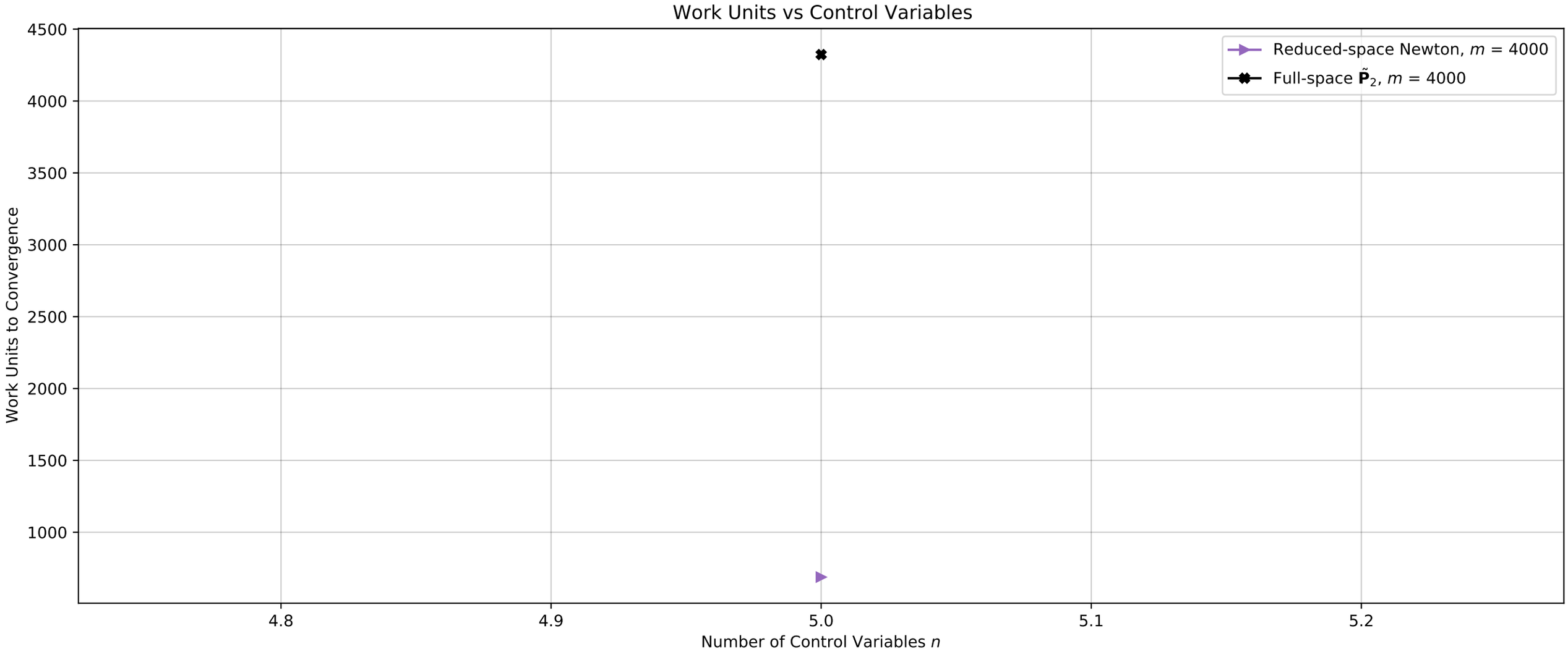

Work Units vs Control Variables
Full-space $\tilde{\mathbf{P}}_2$, m = 4000
Work Units to Convergence
4500
4400
4300
4200
4100
4.8
4.9
5.0
5.1
5.2
Number of Control Variables n

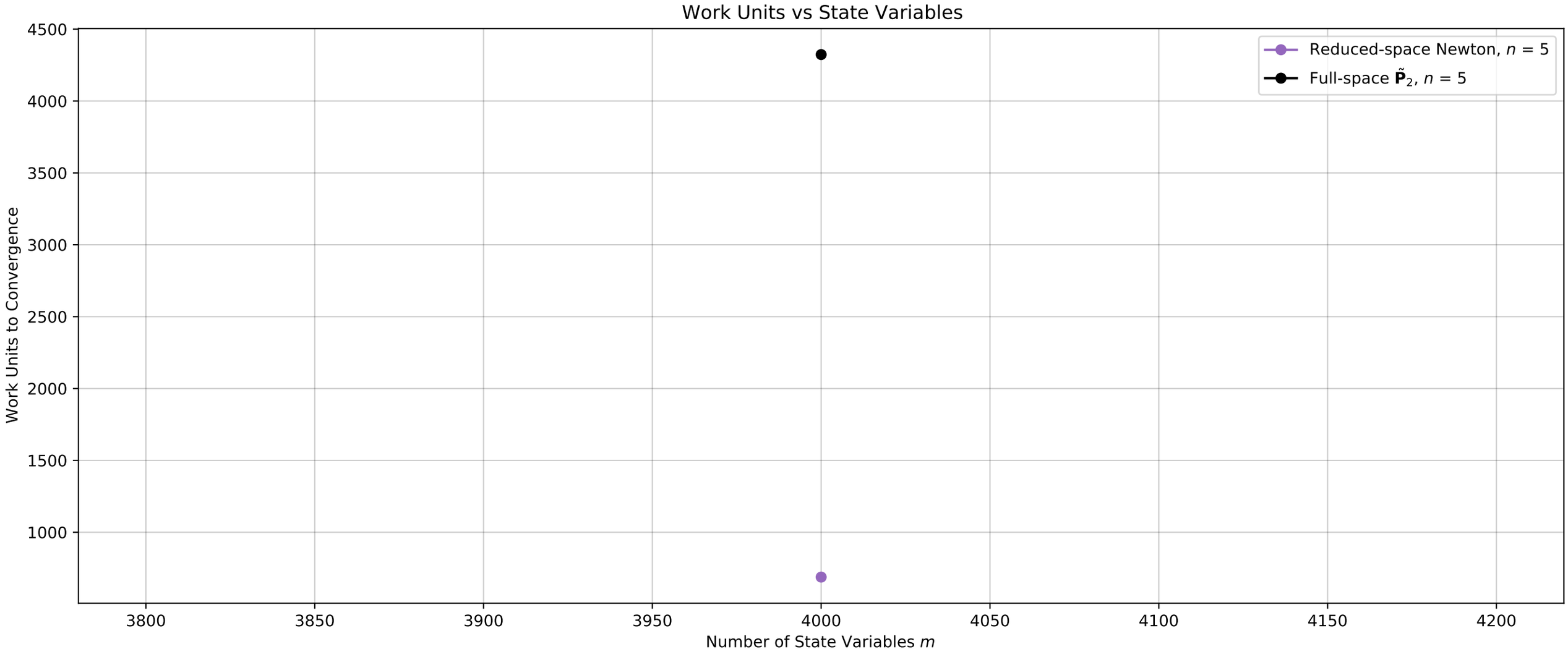

Total Subiterations vs Control Variables
Full-space $\tilde{\mathbf{P}}_2$, m = 4000
Total Subiterations to Convergence
1020
1000
980
960
940
920
4.8
4.9
5.0
5.1
5.2
Number of Control Variables n


Work Units vs Control Variables
Reduced-space BFGS, m = 4000
Reduced-space Newton, m = 4000
Work units to Convergence
700
600
500
400
300
200
100
0
4.8
4.9
5.0
5.1
5.2
Number of Control Variables n


Reduced-space Design Cycles vs Control Variables
Reduced-space BFGS, m = 4000
Number of Design Cycles to Convergence
31.5
31.0
30.5
30.0
29.5
29.0
28.5
4.8
4.9
5.0
5.1
5.2
Number of Control Variables n


1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Work Units vs Control Variables
Work Units to Convergence
4500
4000
3500
3000
2500
2000
1500
1000
4.8
4.9
5.0
5.1
5.2
Number of Control Variables n
Reduced-space Newton, m = 4000
Full-space $\tilde{\mathbf{P}}_2$, m = 4000


Work Units vs State Variables
Work Units to Convergence
Number of State Variables m
4500
4000
3500
3000
2500
2000
1500
1000
3800
3850
3900
3950
4000
4050
4100
4150
4200
Reduced-space Newton, $n = 5$
Full-space $\tilde{\mathbf{P}}_2$, $n = 5$