

Projecting Productivity Growth: Lessons from the U.S. Growth Resurgence

Dale W. Jorgenson
Harvard University

Mun S. Ho
Resources for the Future

Kevin Stiroh*
Federal Reserve Bank of New York

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*The views expressed here are those of the author only and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

The U.S. Productivity Revival

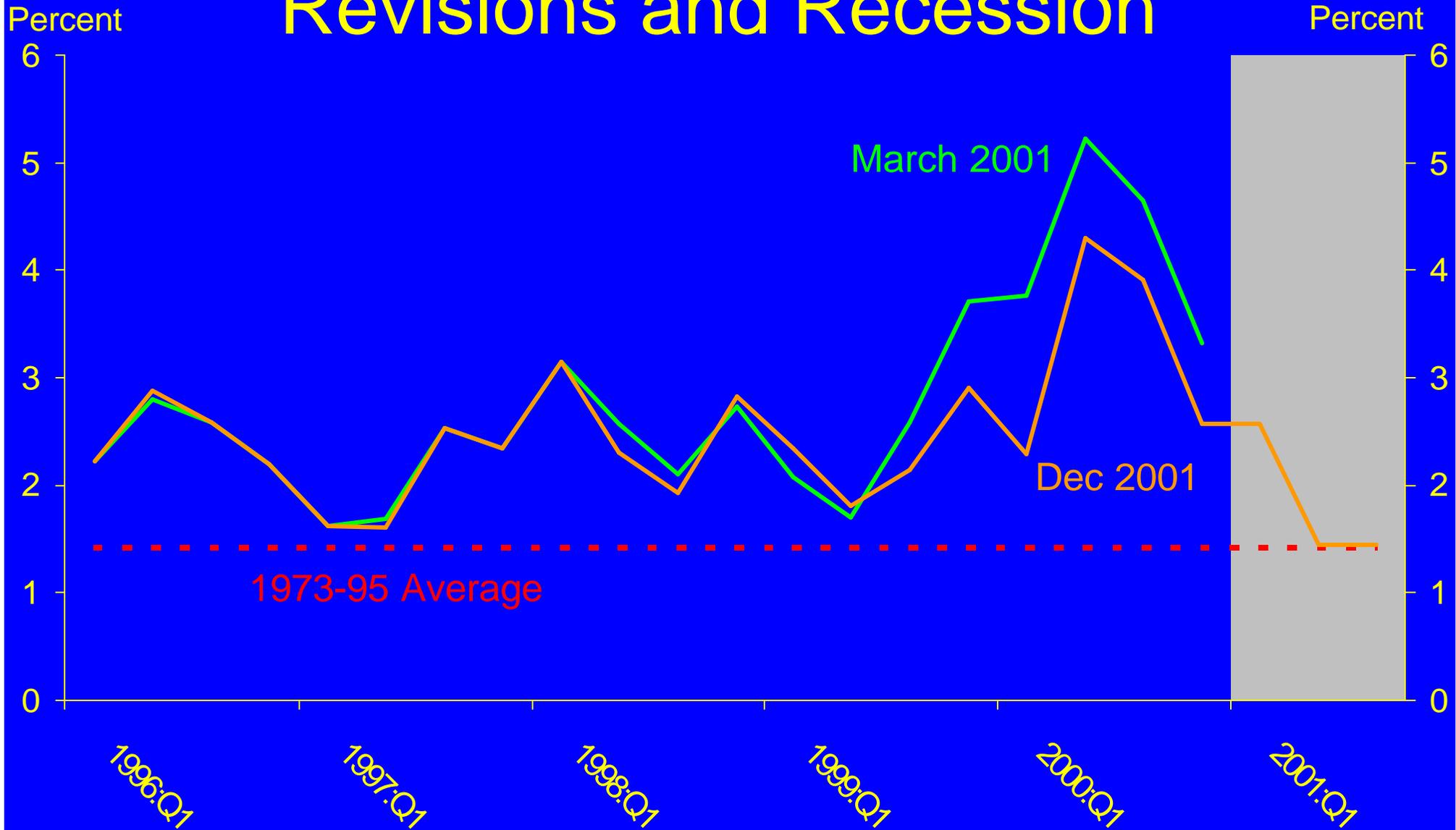
- **Well-known resurgence of productivity after 1995**
- **Increased pessimism recently**
 - Downward revision to GDP
 - Cyclical slowing of productivity

Productivity Surged after 1995...



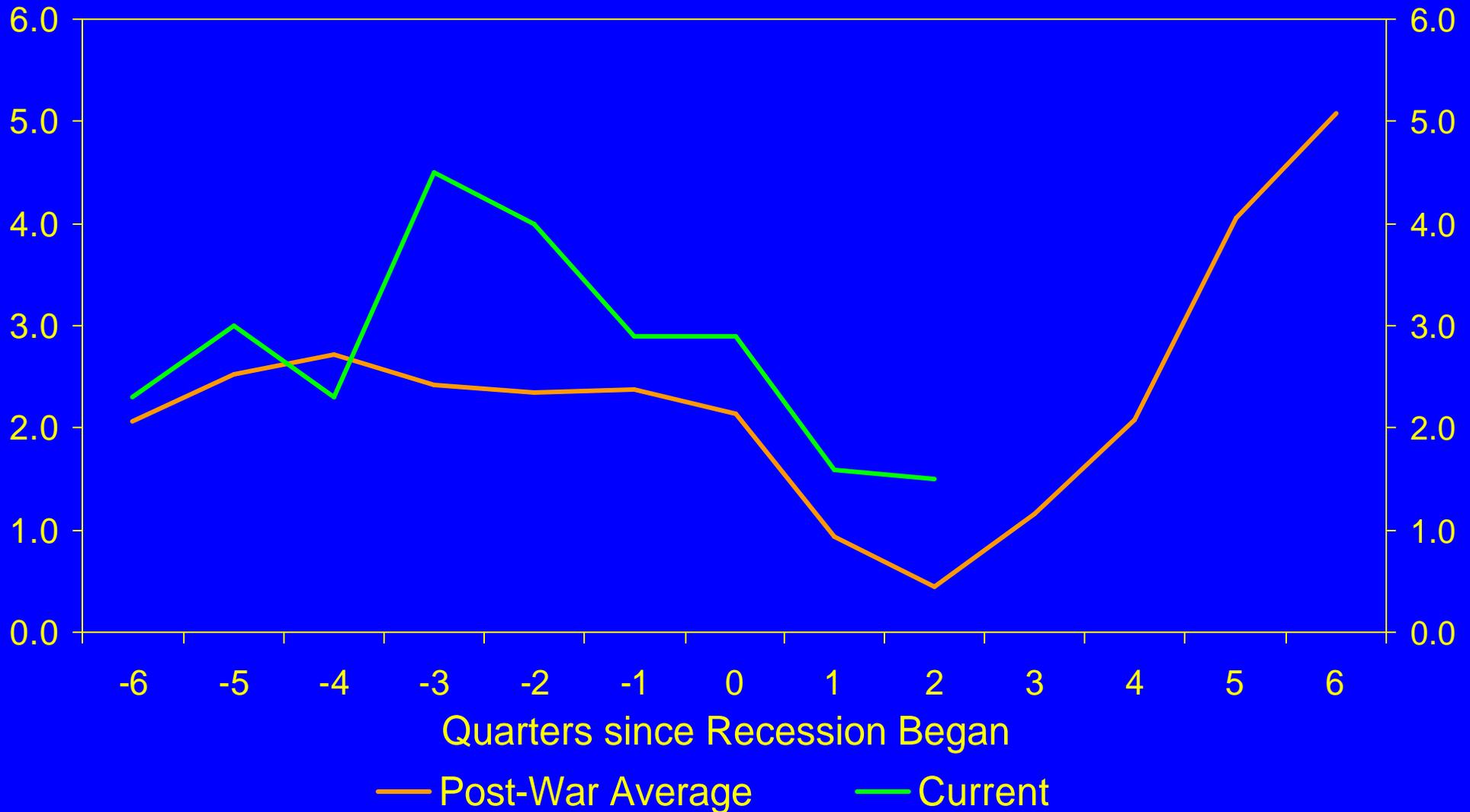
qtr productivity growth in nonfarm business sector.

...and Remains Strong Despite Revisions and Recession



qtr productivity growth in nonfarm business sector. Shaded area is NBER recession period.

Productivity Slows in Recession



4-quarter business sector productivity growth.

The U.S. Productivity Revival

- **Well-known resurgence of productivity after 1995**
- **Increased pessimism recently**
 - Downward revision to GDP
 - Cyclical slowing of productivity
- **Key question:**
 - What happens next?**

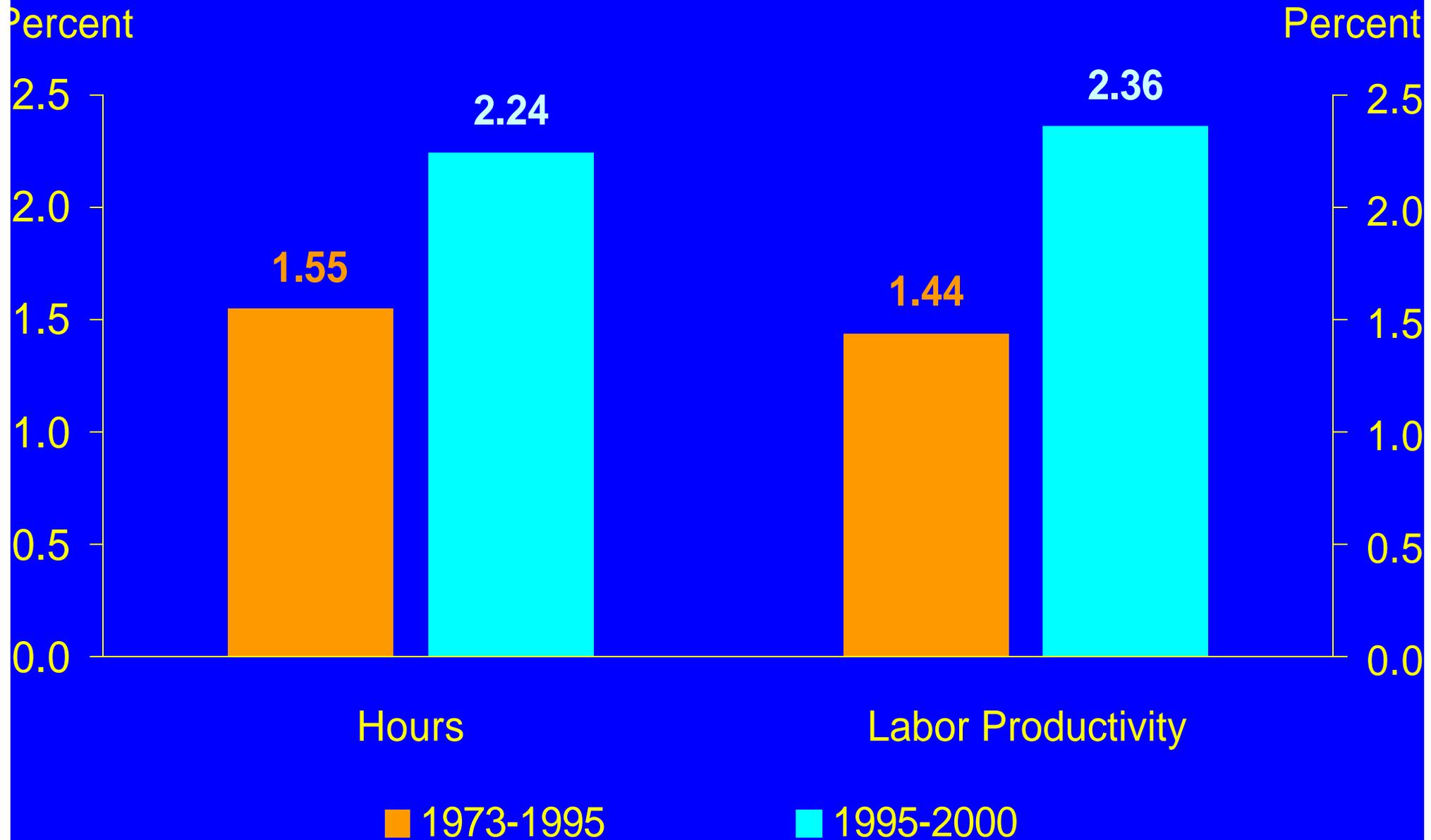
Two Goals of this Paper

- **Document the post-1995 sources of growth**
 - Incorporate 2001 GDP revisions
 - Focus on role of IT
 - Jorgenson and Stiroh (2000), Oliner and Sichel (2000)
- **Provide a simple projection of future growth**
 - Abstract from business cycles
 - Highlight uncertainties surrounding IT

Reviewing the Historical Record

- **Compare 1995-2000 to 1973-1995**
 - Examine sources of output and labor productivity
 - Incorporate revised output and investment data
- **Data issues**
 - Broadly defined output Includes housing services, non-profits, and service flow from consumer durables
 - Faster hours growth than BLS after 1995

Hours and Labor Productivity Accelerated after 1995



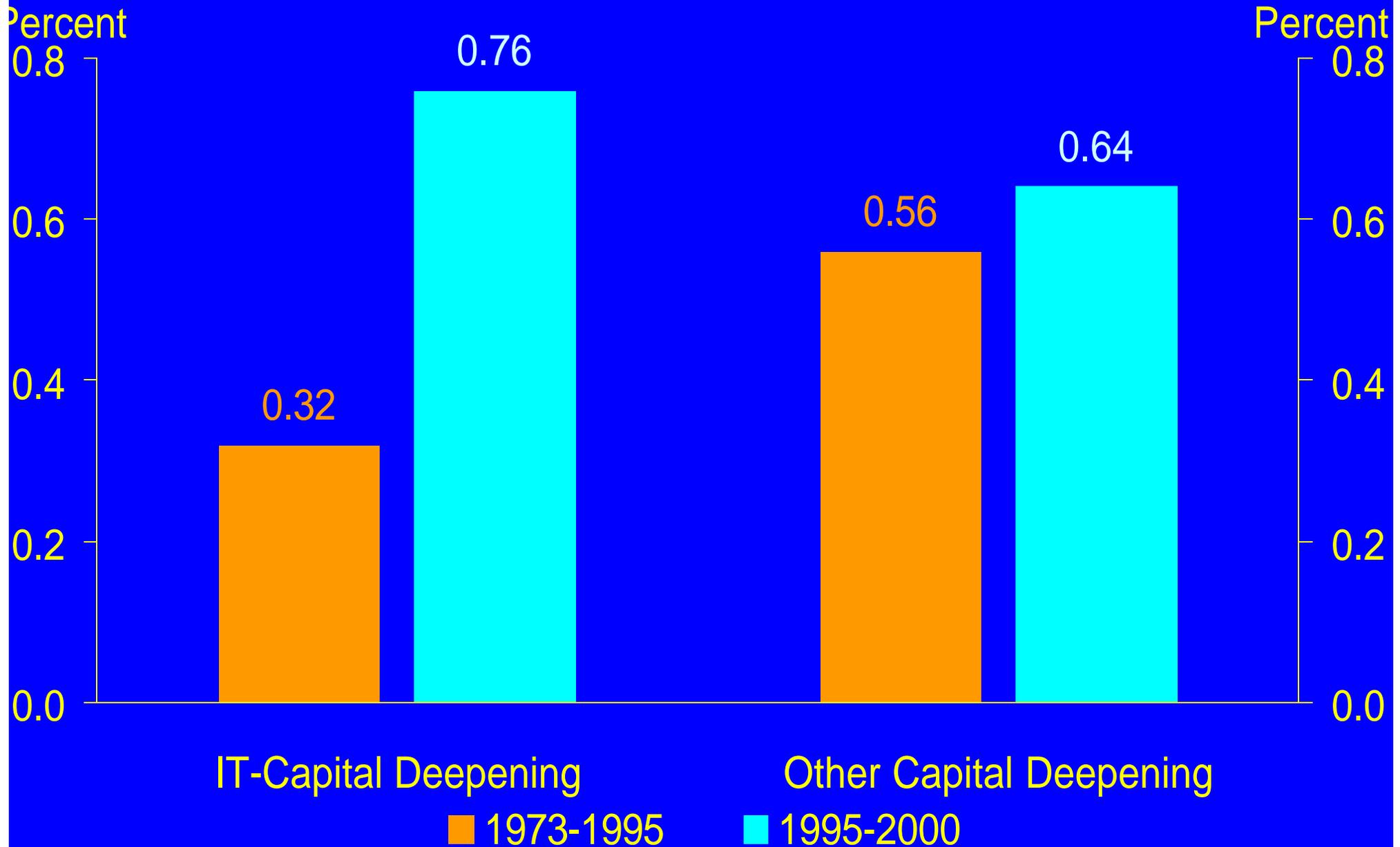
Three Sources of Labor Productivity Growth

- **Capital deepening**
 - Investment provides more/better capital to labor
- **Labor quality**
 - Compositional changes in the workforce
- **Total factor productivity (TFP)**
 - Technology and everything else

What Changed after 1995?

- **Capital deepening increased**
 - IT as an input

Stronger IT Capital Deepening

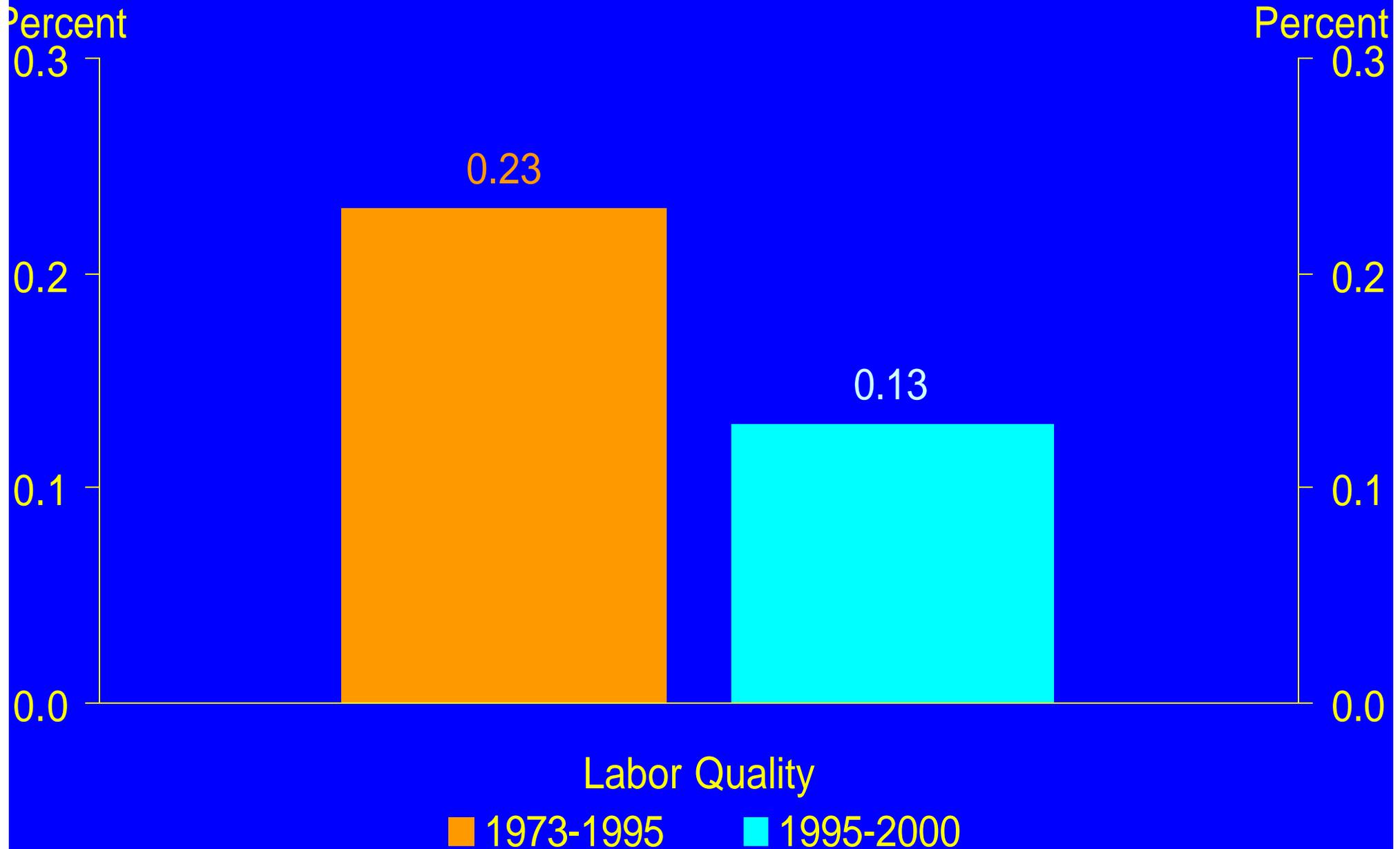


average annual, share-weighted growth rate.

What Changed in the Late 1990s?

- **Capital deepening increased**
 - IT as an input
- **Labor quality growth slowed**

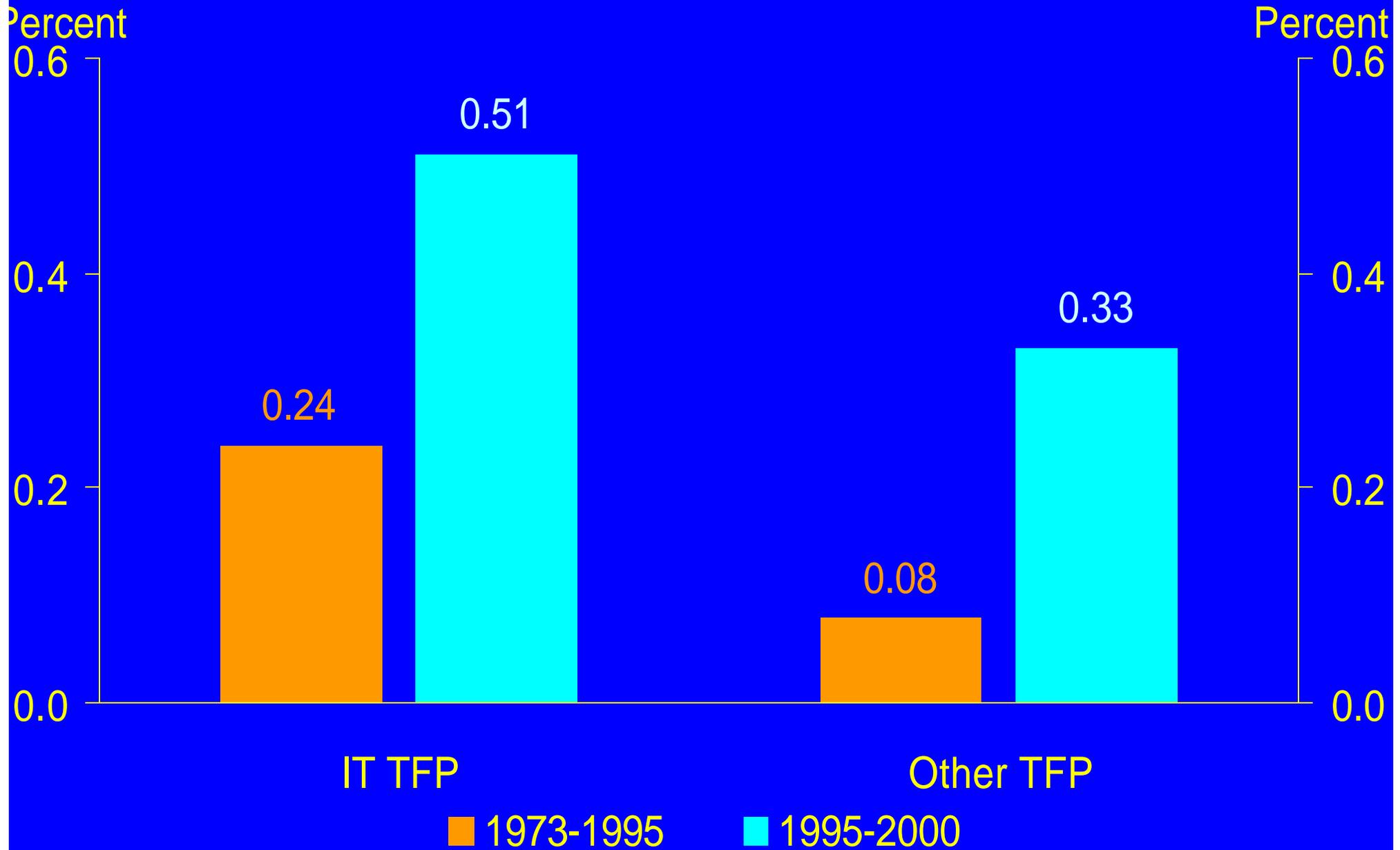
Labor Quality Contribution Falls



What Changed in the Late 1990s?

- **Capital deepening increased**
 - IT as an input
- **Labor quality slowed**
- **TFP growth accelerated**
 - IT as an output

Faster TFP Growth



average annual, share-weighted growth rate

IT Drives the U.S. Productivity Revival

	Change
Growth in Labor Productivity	0.92
Capital Deepening, IT- Inputs	0.44
Capital Deepening, Other	0.08
Labor Quality	- 0.11
TFP, IT- Production	0.27
TFP, Other	0.24

0.71

U.S. Productivity Revival

- **Despite slowdown and revisions, productivity revival remains intact**
 - Official BLS productivity revival is even stronger
- **Both the production and use of IT matter**
 - Results in Jorgenson and Stiroh (2000) and Oliner and Sichel (2000) still hold
 - Shift to two-year product cycle for semiconductors was key change in mid-1990s (Jorgenson, 2001)

Projecting Productivity Growth

- **Two key assumptions to remove transitory effects**
 - Output and reproducible capital grow at the same rate
 - Hours growth matches labor force growth
- **Three scenarios**
 - Pessimistic
 - Base-case
 - Optimistic

Two Sets of Variables

- **“Common assumptions” constant in all scenarios**
 - Hours and labor quality from demographic projections
 - Capital, labor, and IT output shares at historical averages
- **“Alternative assumptions” vary across scenarios**
 - TFP growth in IT production
 - TFP growth elsewhere in the economy
 - Capital quality growth

Calibrating Alternative Assumptions

- **Base-case scenario**
 - “*International Technology Roadmap for Semiconductors*”
 - Eventual reversion to 3-year product cycle
 - Use 1990-2000 means

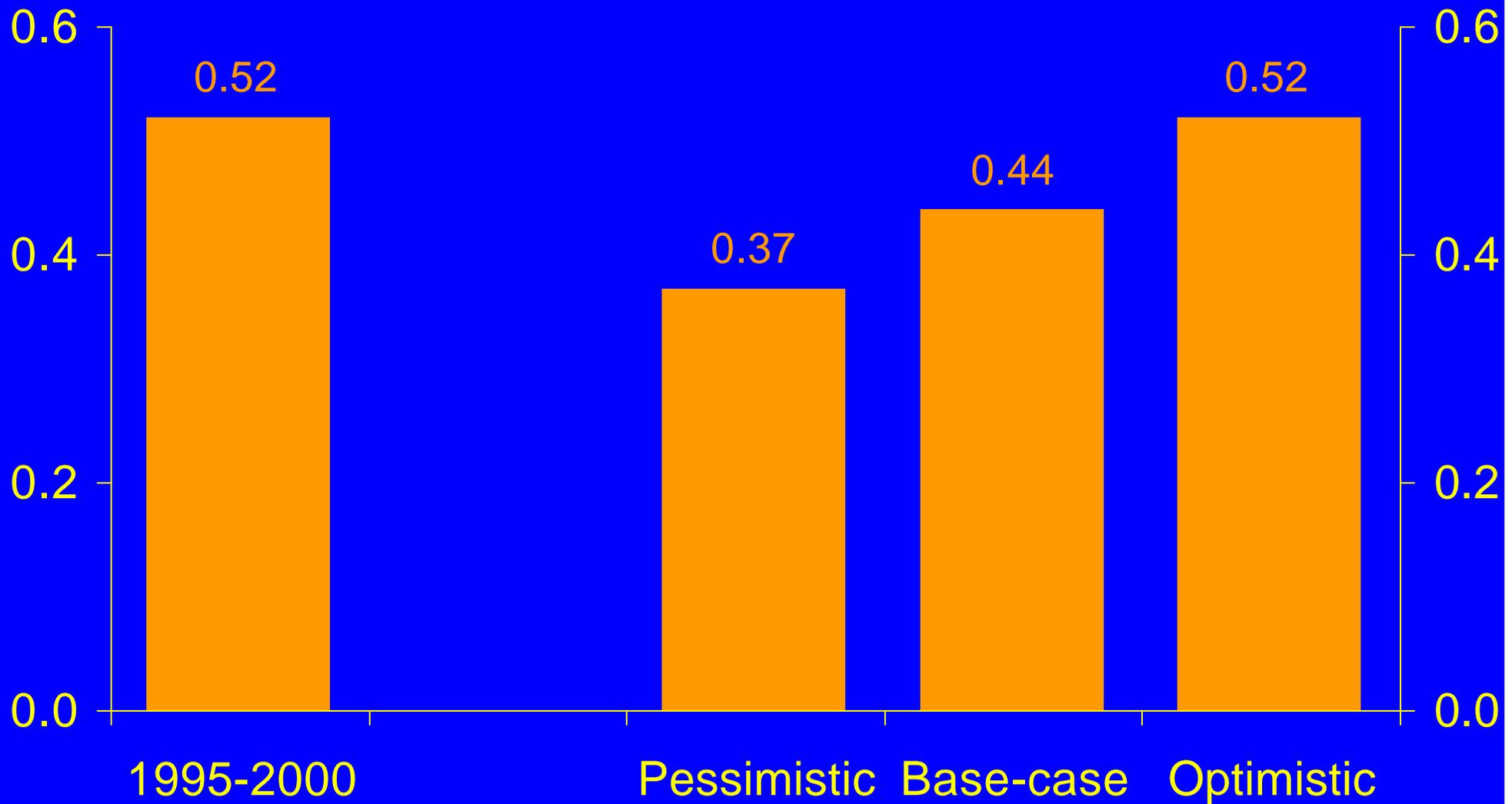
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 - Continuation of the 2-year product cycle
 - 1995-2000 rates continue

Calibrating Alternative Assumptions

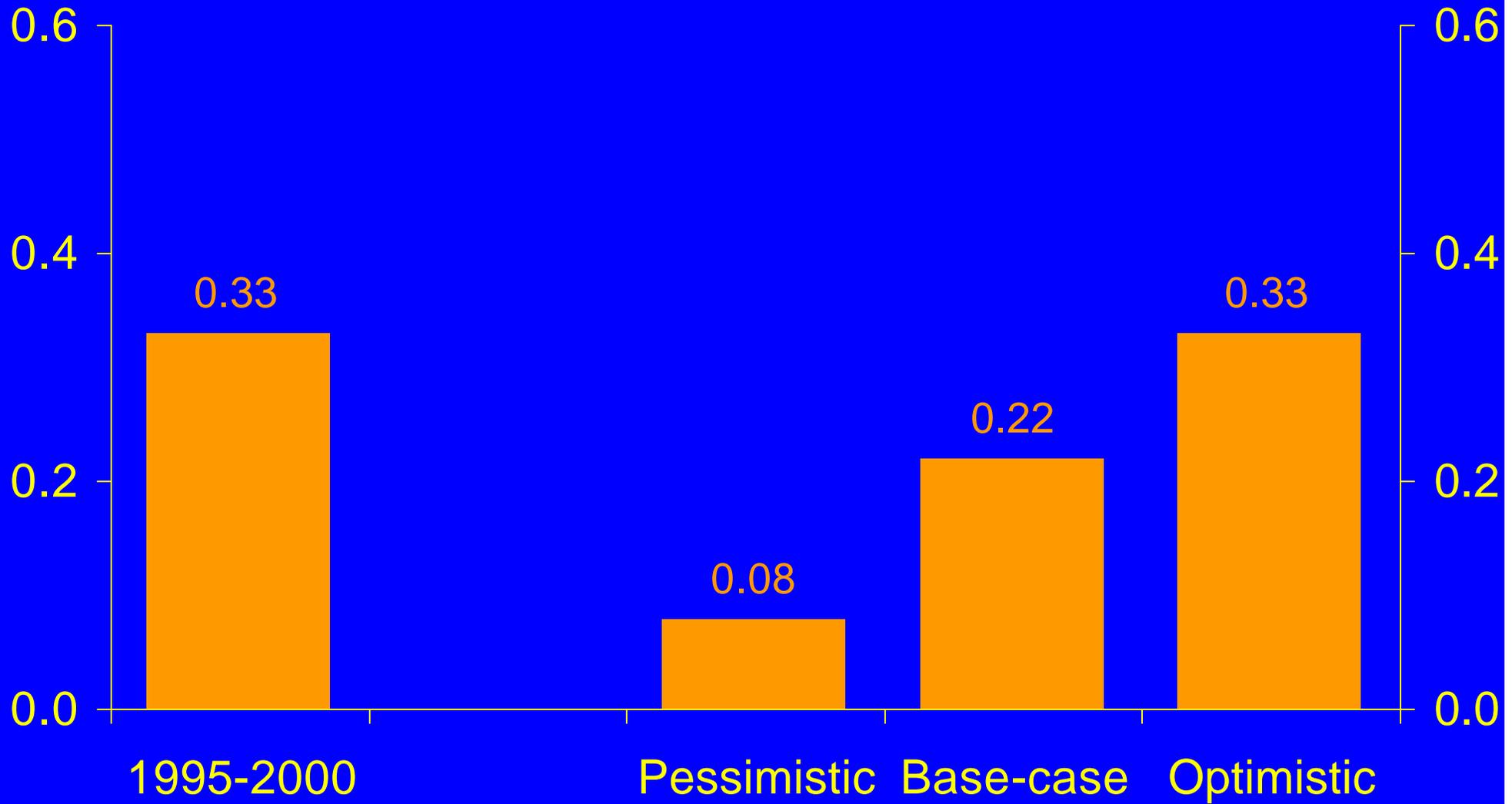
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- **Optimistic scenario**
 - Continuation of the 2-year product cycle
 - 1995-2000 rates continue
- **Pessimistic scenario**
 - Revert to 1973-1995 experience

TFP Contribution from IT



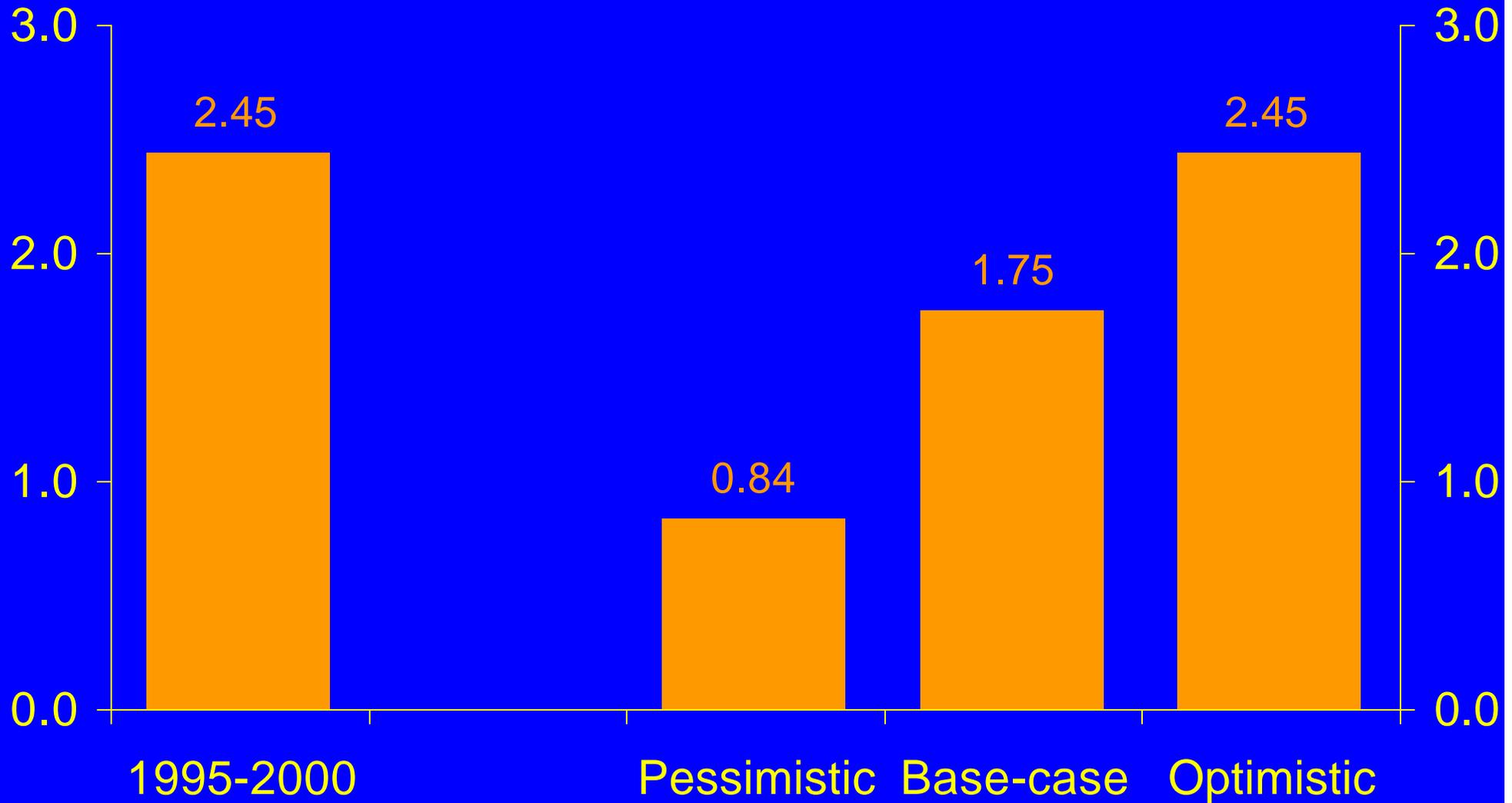
Average annual percentage.

Other TFP Contribution



Average annual percentage.

Capital Quality Growth

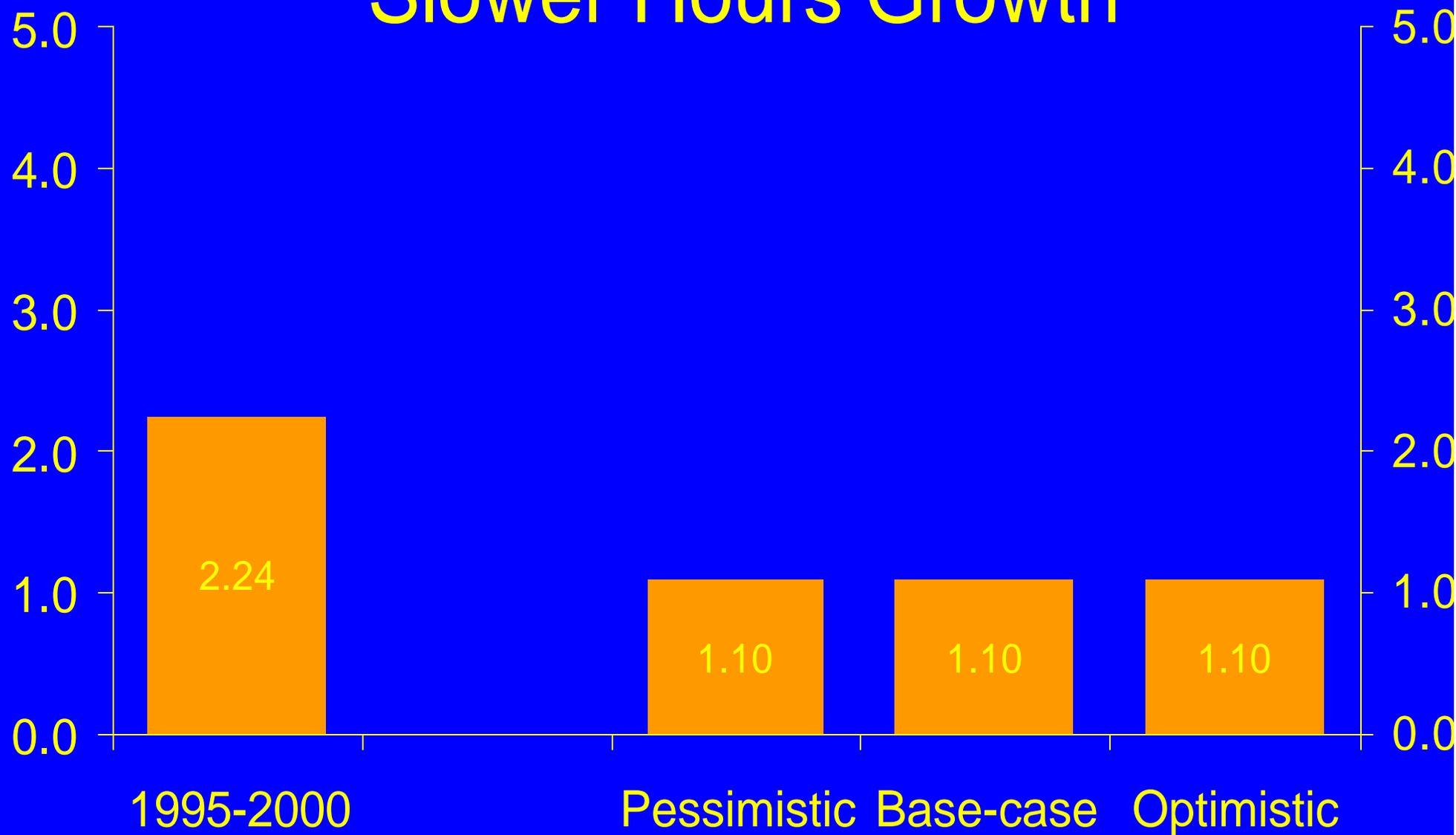


Average annual percentage.

Putting it All Together

- **Demographic assumptions put hours growth at 1.1% per year in all scenarios**

Slower Hours Growth

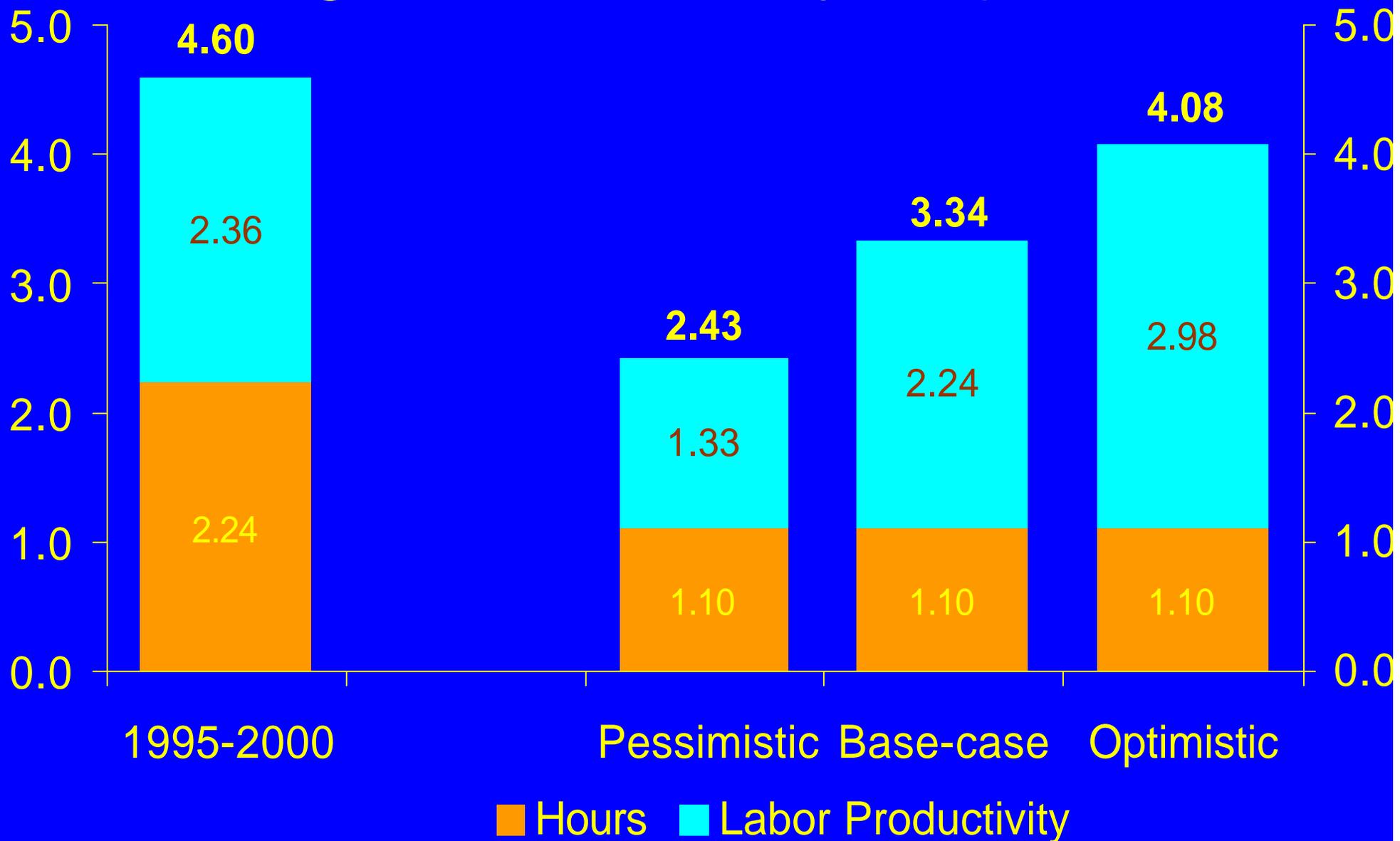


Average annual growth rate.

Putting it All Together

- Demographic assumptions put hours growth at 1.1% per year in all scenarios
- **Other assumptions determine range of productivity growth projections**

Range of Productivity Projections



Average annual growth rate.

Projection Results

- **Base-case productivity just below 1995-2000**
 - Slower capital accumulation is offset by slower hours
 - Slight decline in TFP growth
- **Slower output growth due to slower hours growth**
- **Future of technology progress is the key**
 - Drives IT-related TFP and capital quality growth
 - Considerable uncertainty

Conclusions

- **The U.S. productivity growth remains solid**
 - IT use and production play important roles
- **Post-1995 productivity growth can continue**
 - 2.25% per year seems reasonable
 - Consensus emerging
- **Difficult to make precise projections**

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**Table 1: Growth in Private Domestic Output the Sources of Growth
1959-2000**

	1959-2000	1959-1973	1973-1995	1995-2000	1995-2000 less 1973-1995
Growth in Private Domestic Output (Y)	3.61	4.24	2.99	4.60	1.61
Contribution of Selected Output Components					
Other Output (Y_n)	3.30	4.10	2.68	3.79	1.12
Computer Investment (I_c)	0.16	0.07	0.17	0.37	0.20
Software Investment (I_s)	0.09	0.03	0.09	0.26	0.18
Communications Investment (I_m)	0.07	0.05	0.06	0.17	0.11
Contribution of Capital and CD Services (K)	1.80	1.99	1.54	2.38	0.84
Other (K_n)	1.44	1.81	1.18	1.52	0.34
Computers (K_c)	0.19	0.09	0.20	0.47	0.28
Software (K_s)	0.09	0.03	0.09	0.25	0.16
Communications (K_m)	0.08	0.06	0.07	0.13	0.06
Contribution of Labor (L)	1.15	1.12	1.12	1.38	0.26
Aggregate Total Factor Productivity (TFP)	0.67	1.14	0.33	0.84	0.51
Contribution of Capital and CD Quality	0.47	0.34	0.41	1.09	0.69
Contribution of Capital and CD Stock	1.33	1.65	1.14	1.28	0.15
Contribution of Labor Quality	0.27	0.39	0.23	0.13	-0.11
Contribution of Labor Hours	0.88	0.73	0.89	1.26	0.37

Note: A contribution of an output or input is defined as the share-weighted, real growth rate.

Source: Author's calculations based on BEA, BLS, Census Bureau, and other data.

**Table 2: Sources of Growth in Average Labor Productivity
1959-2000**

	1959-2000	1959-1973	1973-1995	1995-2000	1995-2000 less 1973-1995
Output Growth (<i>Y</i>)	3.61	4.24	2.99	4.60	1.61
Hours Growth (<i>H</i>)	1.54	1.27	1.55	2.24	0.68
Average Labor Productivity Growth (<i>ALP</i>)	2.07	2.97	1.44	2.36	0.92
Capital Deepening	1.13	1.44	0.88	1.40	0.52
IT Capital Deepening	0.32	0.16	0.32	0.76	0.44
Other Capital Deepening	0.82	1.28	0.56	0.64	0.08
Labor Quality	0.27	0.39	0.23	0.13	-0.11
TFP Growth	0.67	1.14	0.33	0.84	0.51
IT-related Contribution	0.23	0.10	0.24	0.51	0.27
Other Contribution	0.44	1.03	0.08	0.33	0.24

Note: A contribution of an output or input is defined as the share-weighted, real growth rate.

Source: Author's calculations based on BEA, BLS, Census Bureau, and other data.

Table 3: Output and Labor Productivity Projections

	1995-2000	Pessimistic	Projections	
			Base-case	Optimistic
			Projections	
Output Growth	4.60	2.43	3.34	4.08
ALP Growth	2.36	1.33	2.24	2.98
Effective Capital Stock	2.94	1.96	2.69	3.28
			Common Assumptions	
Hours Growth	2.24	1.10	1.10	1.10
Labor Quality Growth	0.224	0.265	0.265	0.265
Capital Share	0.438	0.428	0.428	0.428
IT Output Share	0.051	0.051	0.051	0.051
Reproducible Capital Stock Share	0.798	0.804	0.804	0.804
			Alternative Assumptions	
TFP Growth in IT	10.33	7.39	8.80	10.33
Implied IT-related TFP Contribution	0.52	0.37	0.44	0.52
Other TFP Contribution	0.33	0.08	0.22	0.33
Capital Quality Growth	2.45	0.84	1.75	2.45

Notes: In all projections, hours growth and labor quality growth are from internal projections, capital share and reproducible capital stock shares are 1959-2000 averages, and IT output shares are for 1995-2000. Pessimistic case uses 1973-1995 average growth of capital quality, IT-related TFP growth, and non-IT TFP contribution. Base case uses 1990-2000 averages and optimistic cases uses 1995-2000 averages.
