

# Wireless Communications and Technology Substitution

## What S-Curves Reveal about Pending Cellular Competition

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This article will review the principal wireless technologies and their emerging competitive positioning. The empirical evidence outlined herein is used to estimate market penetration rates, a probable time of maturity for the industry, and likely points at which some technologies will be sought as substitutes for others. In sum, the article provides a model by which a forecast of market maturation is postulated for the wireless communications industry.

### Wireless Communications at Present

The wireless communications industry continues to enjoy explosive growth as the 1990s unfold. The industry, whose initial burst of growth has been prompted by the moderation of pricing in the cellular arena, is now poised for spectacular expansion. A growing paging sector has experienced market growth in recent years exceeding that attained by cellular providers. Accompanying this growth are the vibrant specialized mobile radio (SMR) and personal commu-

nications services (PCS) industries. Together, the four wireless competitors are poised for rapid growth that may touch virtually every American before 2010.<sup>1</sup> The next 15 years promise exponential market penetration—growth that may generate as much as \$200 billion in annual revenues for the wireless telecom sector by 2012.<sup>2</sup>

The cellular industry, emerging in 1983, has benefited from the absence of direct competition in the “voice” market. In the 12 years following the advent of cellular communications, only enhanced paging services have directly impinged on the growth of the cellular market and its resultant penetration. In recent years, the paging industry has produced market growth that has exceeded that attained by its cellular counterpoint, characterized by a vigorous pricing strategy.

The cutting-edge of uncertainty in the industry today concerns the prospective development of SMR and PCS.

- Are these dynamic new players, capable of eventually supplanting cellular technology as leading providers of voice and other value-added wireless services?
- Are these emerging technologies, or rather, merely complementary providers able only to capture niche markets?
- What of the role of the paging industry?
- Is this merely a “bare-bones” technology, destined to serve consumers who simply cannot afford the higher pricing associated with cellular providers?
- Is, perhaps, paging poised for continued spectacular growth based on incremental improvements in its technology?

These are among the ambiguities implicit in data now surfacing from private researchers, corporations, and government agencies.<sup>3</sup>

### Data and Forecasts

One of the more intriguing elements of the wireless industry in recent years has been the variance at which forecasters have drawn their statistical inferences. The divergence of forecasters and their predictions has been historic since the early 1980s. Both AT&T and the Federal Communications Commission (FCC), for example, predicted in the early 1980s that fewer than one million Americans would be willing to pay for wireless voice communications.<sup>4</sup> In fact, the explosive growth that has unfolded in the industry has astonished even the most enthusiastic prognosticators; in cellular technology alone, 35 million Americans now use analog or digital phones.<sup>5</sup> Just two years ago, majority sentiment among marketers held that not more than 40 million cellular phones would be in use by the year 2000. That statistic has been revised upward by some forecasters to as many as 75 million—and this growth is independent of rising competition by the SMR and PCS industries.

Mounting empirical evidence suggests that virtually all Americans, without regard to age or other significant independent variables, are prospective candidates for wireless services. As noted in the body of data and other information herein, the industry has all of the intrinsic advantages associated with dynamic growth industries based on emerging technologies:

- Underlying value.
- Inherent need.
- Ease of use.
- Positive mass psychology.

We may reasonably infer from the data that the key determinant for optimal market penetration is pricing; thus, the competitive positioning of the four key players will ultimately be a function of that technology which sufficiently lowers price to accommodate the broadest consumer base. Within reasonable parameters of quality and service, price will be the key independent variable responsible for market penetration. The public wants and needs the value-added services—instant communication, security, access, information, mobility—that only this industry can promote.

### Comparative Advantages and Disadvantages

No serious discussion about wireless providers and their pending competitive positioning could be entertained without noting differences in their technical capabilities and attributes. The seminal wireless technology—cellular—has sufficient bandwidth to accommodate large numbers of consumers, and operates within a duopolistic competitive framework. The cellular industry, despite continued technical improvements and digital enhancements, cannot accommodate, however, the enormous demand estimated for the industry at the turn of the century. It is for this reason that the FCC has continued to allocate—at first through essentially “free,” now auctioned licensing—electromagnetic spectrum.<sup>6</sup>

Specialized mobile radio, originated in 1974 as essentially dispatch designated spectrum, has grown modestly in recent years, but is now poised for geometric growth. Major industry players—Nextel, OneComm, and various regional providers—have accumulated SMR licenses throughout the country to form networks potentially competitive to cellular providers. The absence of sufficient spectrum and continuing technical problems have hampered the growth of the industry, but one certainly cannot rule out rising prominence for these competitors should technical problems be relieved.

The enormous spectrum allocated to PCS, dwarfing the combined bandwidth of SMR, cellular, and paging, underscores the greatest potential competitive threat to the voice duopoly. The multiplicity of PCS license holders in each metropolitan market, however, along with serious issues of capital availability, probably means many years will be required to seriously erode cellular’s present “leader” status. The variance in competitive advantages and disadvantages may be seen more concretely in Table 1.

In sum, the cellular, SMR, and PCS industries will divide and shift market share in response to comparative pricing strategies. Pricing will depend very heavily on the established competition unique to each urban, suburban, and rural area. With the recent completion of PCS auctions (a handful of PCS and SMR licenses remain to be auctioned), we are gaining a clearer sense of the positioning of the players. It is comparatively more expensive to build out and maintain cellular and PCS systems as opposed to their SMR and paging counterparts. However, barring major technological improvements in paging and SMR, these latter providers will remain niche players, despite

**Table 1**  
**Competitive Advantages and Disadvantages**

	Cost of Business per Subscriber	Bandwidth	Pricing	Competitive Structure
Cellular	High	Moderate	High	Duopoly
Paging	Low	Minimal	Low	Multiple*
PCS	High	Extensive	Moderate	3 to 6*
SMR	Low	Minimal	Low	Multiple*

\*Depends on location.

Source: J. K. Shaw

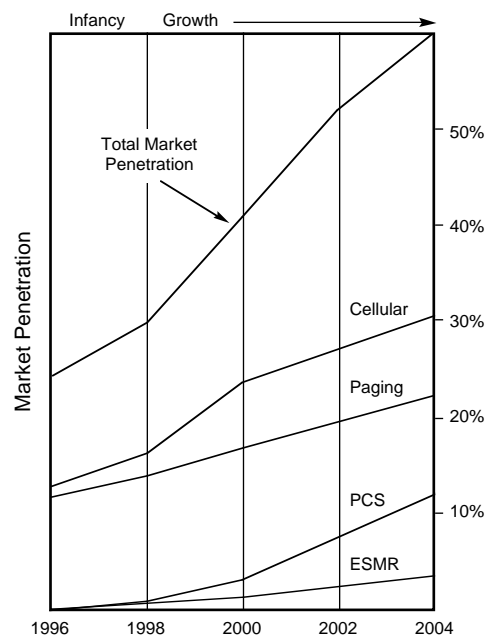
implicit pricing advantages (they control insufficient spectrum to capture substantial market share in the short term). Despite financial and technical constraints, each wireless technology will nevertheless influence price and resultant market share. Taking these advantages and disadvantages in totality, cellular retains the greatest competitive advantage at present. The “head start” it has gained through 13 years of development has produced a seminal, formidable technical and financial knowledge of the market.

**Recent Market Forecasts**

Among the more robust forecasts of the wireless industry market are those generated by Paul Kagan Associates.<sup>7</sup> In late 1995, this firm predicted that cellular subscribers would mushroom to 74.5 million in 2000 from its current level of approximately 35 million. The firm also estimated that SMR subscriptions would expand from fewer than one million to more than three million during the same period. PCS platforms, just now being erected, would generate eight million customers in 2000, exploding to 37.5 million six years later. By 2006, it was estimated that ESMR (enhanced specialized mobile radio) would garner 12 million customers, while cellular providers would maintain a base of more than 93 million. The wireless “voice” market would thus generate 143 million subscribers by the year 2006. This statistic excludes paging providers, whose long-term positioning remains a matter of ambiguity and conjecture. One may reasonably assume that the paging industry would have a primary market base of some 40 million or more subscribers.<sup>8</sup> For paging, the pivotal issue concerns whether technical refinements will permit it to compete effectively with its highly value-added cousins.

A visual depiction of these data underscores the enormous growth projected by Kagan and others (see Figures 1 and 2). We note that cellular’s growth continues unabated until the year 2000. Thereafter, its growth rate diminishes somewhat as PCS and SMR take hold. The concurrent growth in paging remains a matter of debate and contention; we cannot estimate precisely the role of a lower-priced competitor during an era of rising competition between three dynamic players. Is paging posed to capture a “low-end” market, or will it simply be supplanted by a competitor that performs a multiplicity of functions at a declining price? The market penetration rate graphed in Figure 1 for paging presumes continued growth that probably will not diminish until after 2000. In any event, some 60% of the American population could be using one or more communications devices sometime between 2004 and 2006.

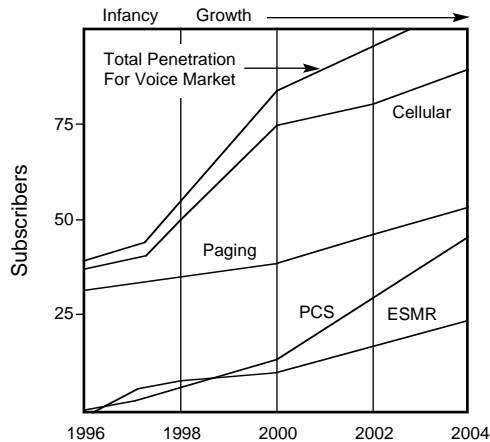
**Figure 1**  
**Comparative Market Performers—Penetration Measured as Fraction of Population**



Source: J. K. Shaw

*Note:* All four technologies are projected to grow until market penetration exceeds 60% sometime between 2004 and 2008. At current projection rates, a minimum of 48% market penetration will be attained by 2004 with respect to voice communication. If enhanced paging technologies are added to this mix, and assuming this technology sustains a subscription rate in excess of 30 million units, as many as 60% more Americans will own a wireless communications device by 2004-2006.

**Figure 2**  
**Comparative Market Performers—Measured**  
**by Projected Growth Rates**



Source: Paul Kagan Associates

Note: Subscription rates are denoted in millions. For purposes of this analysis, enhanced specialized mobile radio, cellular, and personal communications systems are distinguished from their paging counterpart by virtue of their ability to offer unlimited voice communication. The paging curve indicated varies with some forecasts because it is assumed that growth percentages for paging reached their peak during the 1994-1995 period. Pricing for PCS, cellular, and ESMR service will determine future market penetration for paging. For purposes of this discussion, moderate pricing for these voice technologies will undermine growth prospects for paging by the turn of the century. This inference could be challenged by major enhancements in paging applications, including the refined ability to offer voice communication at substantially reduced pricing. Also note that total market penetration for all four technologies will probably exceed 175 million by 2006.

**Applying S-Curve Analysis**

The use of a product S-curve, a method of forecasting prospective market share based on the introduction of technologies aimed at vast consumer markets, has been in use for decades. The S-curve gained prominence for high-technology marketing in 1970 when it was first used to predict the value of research and development in terms of its contribution to productivity.<sup>9</sup> In essence, the S-curve, as applied to measuring market growth potential, asserts that:

- (1) The time required to gain a 10% market share is approximately the same as that required to move from a 10% to 90% penetration rate.
- (2) The shift from a concave to convex curve represents a diminishing growth rate in a rising, competitive mass consumer market.

- (3) Product innovation and improvement should become the prime concern of market participants as they move from growth to mature markets.

Competition compels market leaders to behave in this fashion.

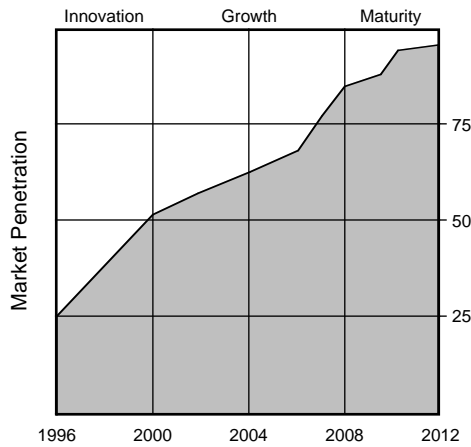
In practice, the S-curve is a strategic tool that pinpoints the time required to introduce and capture the bulk of a ubiquitous consumer market. Because the wireless communications industry fits this criterion, the S-curve has obvious application. We note, for example, that between 1993 and 1995, the cellular industry generated a market penetration of 12.9%. In short, a decade had passed before a 10% penetration rate had been established. We thus infer that a comparable period—approximately 10 or so years—would produce 90% market acceptance.

By this estimation, as many as nine out of 10 eligible consumers would secure a wireless communications device sometime during the period running from 2006 to 2010. There is some implicit imprecision in this forecast—technical problems could impede market growth, for instance—but the dynamics of market acceptance underscore a credibility to the prediction. Even in the absence of significant contributions by SMR and PCS, the industry has already attained a 25% penetration rate when paging is factored with cellular subscriptions.<sup>10</sup>

In Figure 3, we can isolate an S-curve that suggests 90% market penetration for wireless services not later than 2012. A comparable penetration rate could be achieved earlier, of course, if price dropped sufficiently to expand the market base. There are ample precedents for similar and dramatic S-curves throughout history: radio, television, and the videocassette recorder all achieved 90% market penetration defined by a timeframe consistent with the S-curve. The years required to gain a 10% market share approximate the number of years required to move from a 10% to 90% market share.

When the S-curve for wireless communications is adjusted to exclude paging services (see Figure 4), a tactic employed to specify the potential market for voice communications, we note a series of “steps” that market participants are likely to embrace. As the industry unfolds after 1996, we identify the origin of radical innovation in quality, pricing, and service for wireless services. As market share expands, an industry shake-out is inevitable. Before 2008, and perhaps as early as 2004, we are likely to see a substantial number of mergers, acquisitions, and

**Figure 3**  
**Wireless S-Curve Analysis—**  
**Cumulative Impact**



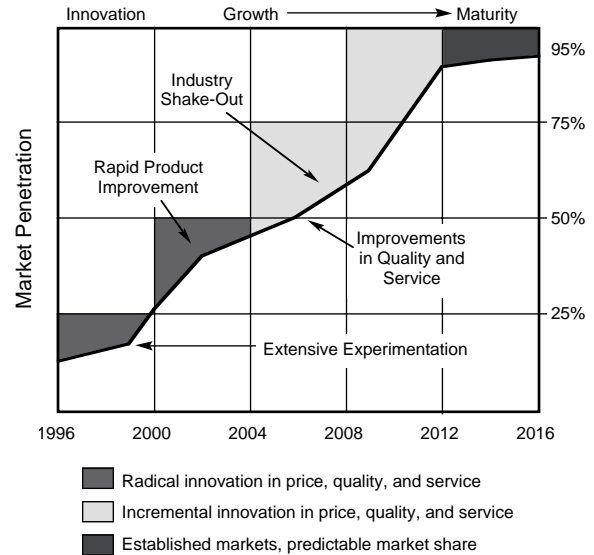
Source: J. K. Shaw

*Note:* Following the initial development of cellular technology in 1983, a penetration rate in excess of 10% was attained before 1995. By this reckoning, and taking into account a standard S-curve adoption rate, a 90% penetration rate could be achieved before 2012. Such a phenomenon would effectively mean that nearly all American households would acquire one or more personal communications devices of some kind within the next 15 years. Should consumer prices drop via competition at a rate faster than projected, a 90% penetration rate is theoretically possible by 2006. The chart above includes the contribution of paging to the wireless mix.

strategic alliances which will only diminish as we approach 90% market penetration. It appears probable that the impending chaos of these consolidations will only abate when we move from 2008 to 2012.<sup>11</sup> The period of maturity which follows thereafter will be characterized by established markets and predictable, sustained market shares. There will be a place for all three primary voice technologies with reliable hardware retaining versatile functionality.

Should this S-curve scenario unfold in a manner characteristic of other mass consumer markets, we cannot identify with certainty the “ultimate victor.” The winner, in the era of mature and established markets, most probably will be either cellular or PCS. Their control of spectrum imparts, with or without major engineering refinements, a strong advantage in this environment. In this case, the consolidations which follow radical innovation during the next eight years will probably determine the dominant market technology. By this time, it may well be immaterial

**Figure 4**  
**Projected Wireless Industry Behavior**



Source: J. K. Shaw

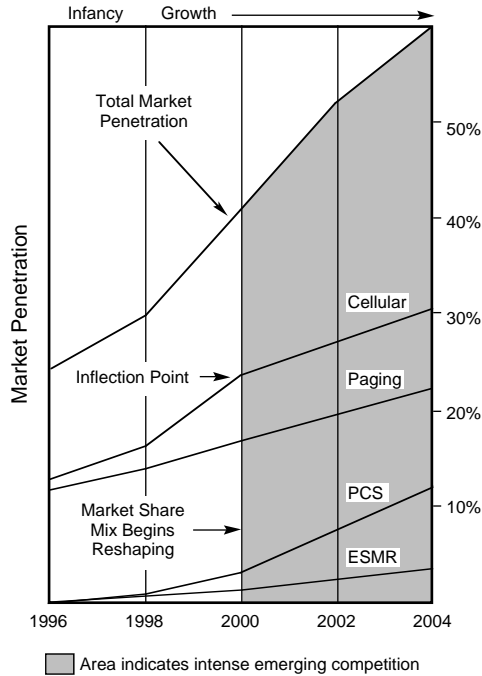
*Note:* Excludes enhanced paging applications. Should the wireless communications industry adhere to traditional S-curve developments characterized by comparable technologies, we can expect major product innovation to differentiate the PCS, cellular, SMR, and paging industries sometime between 2006 and 2008. In other words, an industry shake-out, distinguishing winners from losers, is likely to occur before 2008. While each technology is likely to nominally control at least a niche market, it is probable that one predominant technology will dominate market share.

which technology “wins” such a battle. We may well have networks that are indifferent to the hardware which sends or receives wireless messages. Corporate consolidations resulting in control of spectrum may well be regarded as the most important determinant of market dominance during this era.

### The S-Curve and Prospective Technology Substitution

One of the more intriguing strategic issues confronting wireless providers over the next decade will concern technology substitution. In other words, as we move along the path of the S-curve, will there be a move from one technology to another by consumers? This is a more profound question than one might initially expect. A simple focus on pricing is not sufficient to respond to the question. History confirms that market acceptance is often filled with subtlety and even mass psychology.

**Figure 5  
Prospective Technology Substitution**



Source: J. K. Shaw

*Note:* As each of the four principal wireless technologies develops into the next century, the graph designates cellular technology as the first to reach an inflection point: the shift from concave to convex market penetration implies a market opportunity for the three remaining technologies. It is at this point that cellular wireless service may reach its highest level of penetration. One or more of the remaining technologies is likely to seize an expanding market share.

As previously indicated, that point on an S-curve which represents a transition from concave to convex growth signifies a diminished growth rate. These inflection points signal vulnerability to a market leader in a rising consumer market in which competition mounts. We note such an inflection point for cellular technology in the year 2000. Although cellular continues to grow at a substantial rate, PCS and SMR technologies accelerate their growth and penetration rates in a rising tide (see Figure 5). This period, 2000-2006, will be an era of severe competition where the market leader will have to innovate in response to aggressive emerging technologies. It is improbable that cellular can capture more than one-third of total market share during this period, and it is a distinct possibility that PCS (exploiting its bandwidth and economies of scale) could significantly erode cellular market share. Con-

tinued technical improvement with commitment to marketing and after-sales service will define market success during this period. It is quite possible that market share will be volatile during this era, with SMR and PCS capturing an expanding market at cellular and paging's expense. It is unclear whether the rising prominence of these alternative technologies will reflect a niche status or serious threat to cellular's long-term survival.

Should business consolidations reduce the number of PCS providers to two or three per market (rather than the four to six participants now licensed), PCS could be the "natural substitute" for cellular telephony. With ESMR relegated to a largely niche dispatch role, a fight between cellular and PCS for rising market share in an exponentially growing market seems inevitable. To succeed as a "substitute," PCS must make its mark (note cellular's inflection point and diminished arc) during the first six years of the next decade, and its most serious obstacle is the presence of so many "sister competitors." Therefore, the extent to which PCS will succeed will depend to a large degree on its capacity to sort out viable, consolidated competition to the enduring duopoly.

### Jumping the S-Curve and Strategic Positioning

When technologies in growing consumer markets experience a change of arc in their growth rates, potential market vulnerability should signal major product improvement. In effect, a mature technology can "jump" an existing S-curve and once again experience an ascending concave arc. The logic implicit in this strategy is obvious, and, for the cellular industry, the key turning point is likely to occur sometime around the year 2000. Yet, in the past, a number of technologies have not been improved to accommodate such a strategy. We note these cases as illustrations of lost opportunity and eventual product decline.

Historically, companies have hesitated in "jumping" to a new S-curve for a number of reasons. Often, product improvement that might have resulted in an elegant move from established to new S-curves has been thwarted by:

- (1) A misinterpretation of market data.
- (2) Reticence in taking on new business risk.
- (3) Overlooking rising competition from alternative technologies.
- (4) Failure to satisfy consumers during period of expanding numbers of alternative suppliers.

Cellular providers could be undermined by overconfidence during the next decade if they presume that PCS, paging, and SMR providers can achieve no more than marginal market shares. Success often spoils leaders who presume that their early entry to market secures permanent advantage. No such presumption is valid in the wireless industry.

It has often been assumed that the most effective way of capturing a rising market share in a rising consumer market is to innovate a technology, grow with the market, and dominate pricing in the early years of minimal competition. It is this tactic that has characterized the growth of the cellular industry since the 1980s. The primary disadvantage associated with this tactic is, of course, the extraordinary expense associated with product innovation and “consumer education.” The front-end costs are seen as being fully justifiable during an era of an expansive S-curve.

Although PCS and ESMR are different forms of wireless telephony, they are essentially identical in their ability to offer consumers a similar multiplicity of services. Therefore, increasingly, it will be less significant as to who the market innovator has been, and it is possible through incremental improvement to compete with this established technology. PCS and ESMR have the opportunity to learn from mistakes made by the cellular industry: Technical, financial, and market lessons painfully learned in cellular can lead to sustained, incremental improvements for these upstart technologies.

It has become axiomatic in the computer industry, for example, that “first to market acceptance” is substantially more important than being first to market.<sup>12</sup> Seventy-five percent of Americans do not have access to wireless communications at present, and it matters little to them which technology they employ. Consumers are interested in procuring that form of wireless telephony which, predictably, is predominant in pricing, quality, and service.

The ascending concave arc now characteristic of the industry S-curve affords competitors an exceptional and, perhaps, unprecedented market opportunity. It is unlikely that such an opportunity will return after the year 2006. *nq*

<sup>1</sup> See Paul Kagan Associates, Inc., *PR Newswire* (October 5, 1995), for elaboration of industry forecasts through the year 2006. The data cited in Figures 1 through 3 forms this article’s market projections for ESMR and PCS technologies.

<sup>2</sup> Kagan forecasts annual revenues of approximately \$83 billion for cellular, PCS, and ESMR services by the year 2006. If paging services are added to the mix and a 90% penetration rate is achieved by the year 2012, this figure could approach \$200 billion.

<sup>3</sup> The most nebulous factor in forecasting market growth for these technologies remains engineering and technical improvement. For purposes of this analysis, it is assumed that paging is a complementary service that will not approach the value-added functionality associated with its three competitors. Should a major technological breakthrough occur such that paging is enhanced to offer unlimited voice communication, for instance, the industry’s S-curve and ascending concave arc will force a profound industry shake-out well before 2010.

<sup>4</sup> G. Calhoun, *Digital Cellular Radio* (Boston: Artech House, 1988).

<sup>5</sup> Kagan’s estimate for 1995.

<sup>6</sup> The FCC ended “first-come, first-served” SMR licensing in 1995. Such paging licensing ended in 1996. All PCS licenses were subject to auctions which began in 1994. Cellular licenses were granted on a lottery basis from 1992 through 1984. All future spectrum, according to the Telecommunications Reform Act of 1996, is to be auctioned (with the exception of digital television, which is subject to different rules of allocation).

<sup>7</sup> Kagan Associates is among the more accurate (and optimistic) of private forecasters, and properly anticipated the exponential growth rate of cellular and competitive technologies since 1990.

<sup>8</sup> It is estimated that the paging industry will generate something on the order of 30 million subscribers by 1997. Growth rates projected after this point vary widely from approximately 40 million to as many as 60 million within the next eight years.

<sup>9</sup> P. Asthana, “Jumping the Technology S-Curve,” *IEEE Spectrum* (June 1995):49.

<sup>10</sup> Kagan, *op. cit.*

<sup>11</sup> Figure 4 elaborates a scenario of building blocks leading to this phenomenon. See H. Dent, *Job Shock* (New York: St. Martin’s Press, 1996), p. 242.

<sup>12</sup> Asthana, *op. cit.*, p. 52.