



## **Procurement Risk Management (PRM) at Hewlett-Packard Company**

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In 1999-2000, HP was faced with significant price increases and an availability shortfall for Flash memory used in HP's highly profitable printer lines. Demand for Flash memory grew exponentially due to increasing demand from cell phone manufacturers, and an expected shortfall in Flash memory threatened printer shipments.

To assure future availability of Flash memory, and protect HP's printer profits, HP decided to enter into a binding long-term contract with a major Flash memory supplier. The uncertainty in the future price and availability of Flash memory, and HP's own demand uncertainty for Flash memory, made specifying the terms and conditions of this contract very difficult. HP had to evaluate the following to avoid a risky and imprudent long-term commitment:

- What should we pay for flash memory over the next few years and how should we structure our payments?
- How much should we buy and how should we structure delivery terms?
- How long a horizon should the contract cover and when is the best time to sign the agreement?
- What provisions should be included to secure compliance?

The Procurement Risk Management (PRM) program was launched at HP in August of 2000 to develop and standardize methods for addressing these kinds of questions. As a result of this work, and successful implementation for a range of strategic commodities and business units, risk management is becoming a cornerstone strategy for procurement at HP. Procurement and supply chain professionals at HP are taking lessons from Wall Street to manage uncertainty in



component markets. And, the lessons are paying dividends for HP, its suppliers and customers. This article describes HP's procurement risk management approach and successes to date.

#### 1. Procurement uncertainties can significantly impact the company's bottom line

HP's procurement community knows that uncertainty in product demand, component price and component availability result in significant procurement risks. Manufacturers like Ford, Cisco and Dell know these risks all too well. Ford posted a \$1 billion loss on precious metals inventory and forward contract agreements in December 2001. Cisco took a \$2.5 billion inventory write-down in April of 2001 due to weakening demand for networking products. And, Dell's announcement in October 1999 about the impact of higher-than-expected memory prices resulted in a 7% decline in their stock in one day.

The hi-tech components that HP purchases can exhibit even more volatility. In the case of Ford, palladium prices doubled over the year 2000 and decreased by over 50% in 2001. By comparison, the price of DRAM memory used by HP dropped by over 90% in 2001 and more than tripled in 2002.

Coupled with this volatility of prices is significant uncertainty in the availability of hi-tech components such as memory and other semiconductor products. In periods of high demand, hi-tech suppliers place OEMs such as HP under allocation where by they supply only a fraction of an OEM's total demand. Availability uncertainty can also result from supply and delivery



disruptions, like the earthquake in Taiwan in late 1999, or quality issues with a supplier.

In addition to component price and availability uncertainty, manufacturers face substantial product demand uncertainty. The dramatic drop in the demand for telecom and networking equipment in 2001-02 after several years of breath-taking growth is a case in point. Demand uncertainty has caused cycles of product and component shortages followed by inventory build-ups and write-downs such as Cisco's \$2.5B loss in April 2001.

In mid-2000, HP signed the long-term binding contract with a major supplier to actively manage the substantial future price and availability uncertainty of Flash memory. There were significant 'incremental' risks to HP in entering into the forward contract. For example, if HP demand weakened, then committing to buy a fixed quantity would result in significant inventory buildup and write-offs. If Flash memory prices dropped, HP would pay more through the fixed-price commitment than its competitors.

To ensure that such incremental risks due to the forward contract were minimal and more importantly manageable in the future, we developed a quantitative framework to compare in detail the long-term demand, price and availability uncertainty scenarios for Flash memory, and compare those to the quantity and price HP committed to in the contract.

The long-term binding contract for Flash memory signed in mid-2000 thus set the course for the active management of procurement uncertainties and risks at HP. Over the past 5 years, HP has



developed, based on financial-engineering approaches used on Wall Street, 1) a framework to quantify the impact of product demand, component price and availability uncertainty on revenue, costs and profits, 2) software tools to support the risk management process, and 3) a rigorous procurement risk management process to proactively manage procurement uncertainties and risks.

## 2. Technical challenges in managing procurement uncertainties.

Current supply chain management (SCM) practices emphasize the management of demand and availability uncertainties through inventory buffering strategies, with little if any focus on managing component cost uncertainties. Financial engineering practices, such as that used on Wall Street for stocks, bonds and currency, enable the management of cost uncertainty though not demand and availability uncertainties. Further such cost uncertainty management techniques require the availability of traded risk management instruments such as call and put options; such instruments are not available for hi-tech components. For hi-tech components such as memory and flat-panel displays, demand, cost and availability uncertainties are equally important, requiring that these uncertainties be managed together.

These challenges implied that existing supply chain management and financial engineering practices could not be directly applied to the management of procurement risks of hi-tech components. The PRM framework that HP invented enables the simultaneous measurement and

management of demand, cost, and availability uncertainties, as described below. Proprietary software tools were also developed from scratch to support PRM, since existing SCM and ERP software based on the current SCM theory do not support risk management.

### 3. The Procurement Risk Management Framework

#### 3.1. Measuring uncertainty using the scenario approach

HP's procurement risk management approach involves 1) measuring uncertainties associated with buying commodities, and 2) managing these risks using structured contracts.

The first step in this process is always estimating uncertainties. Component demand, price and availability uncertainty over time are captured using forecast scenarios. Typically, each of these uncertainties is represented by high, base and low scenarios over time, along with likelihood estimate for each scenario, as shown in Fig. 1. Current forecasting approach at most companies emphasize 'point' forecast, which in the PRM approach is represented by the base scenario. The

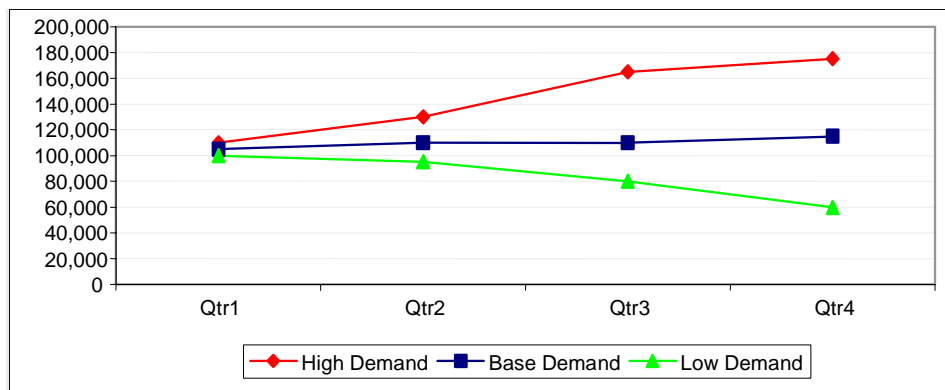


Fig. 1. Scenarios are used to quantify uncertainty in component demand, cost and availability, as illustrated here for demand forecasts. High, base and low scenarios are defined as the 90<sup>th</sup>, 50<sup>th</sup> and 10<sup>th</sup> percentiles, respectively, of the uncertainty distribution for demand, cost and availability.



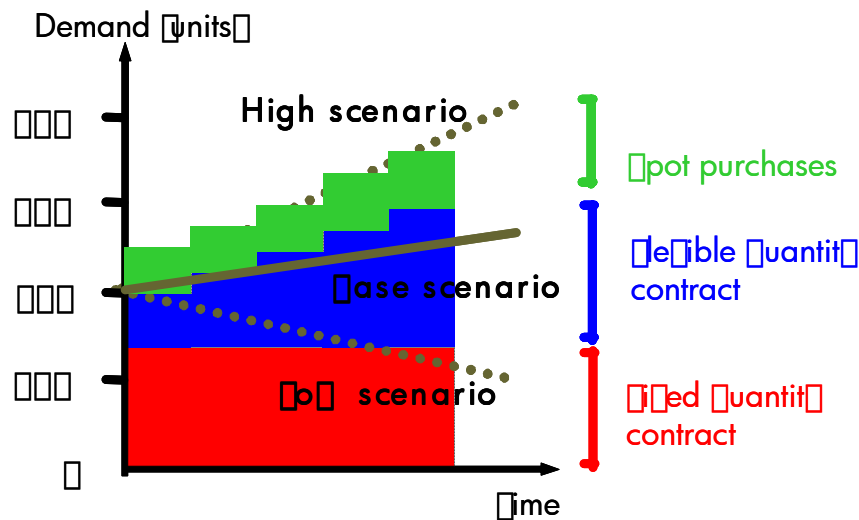
uncertainty around the base scenario is captured by the low and high scenarios. An estimate of the correlation between demand, price and availability uncertainties is also captured. Once the procurement uncertainties are modeled, the current procurement strategy can be analyzed to measure the procurements risks involved.

### 3.2. Managing risks using structured contracts with suppliers

Once the demand, cost and availability uncertainties are quantified using scenarios, the risks associated with these uncertainties are managed using structured contracts with suppliers.

Structured contracts are binding commitments between HP and the supplier, with complex combination of quantity and pricing terms. Quantity terms include fixed and flexible quantity contracts, and percent of total-available-market (TAM); pricing terms include discount-off of market price, fixed price, price-caps and price-floors.

### 3.3. Applying the PRM approach



Estimating demand uncertainty illustrates the PRM approach and has significant benefits of its own. Most forecast process has consistent error. By quantifying the uncertainty, we can segment demand according to its uncertainty or risk, as shown in Fig. 2. Put simply, any company who has been successfully selling products and services is reasonably certain that next month they will sell at least one product or sell to one client. However the certainty associated with selling 100 products or to 100 clients is less, perhaps much less, certain. This difference in uncertainty, or risk, is used to segment demand according to the probability it will occur. Once completed, management teams look for low cost, efficient means to satisfy “certain” demand, and more flexible methods to satisfy likely, but “less certain” demand. Approached this way, the risk and cost to supply products and services is reduced. This means less inventory, less



inventory risk, better service levels to customers, lower costs, and more competitive product pricing. HP supply chain teams estimate that total supply chain costs could be lowered by as much as 20% by this approach.

For buyers and commodity managers, segmenting demand increases opportunities for creative contracting with suppliers. For certain demand, minimum quantity forward contracts assure supply at very low prices. Suppliers are often willing to discount for firm quantity commitments because it allows them to manage capacity more efficiently. Committed volumes can be scheduled during non-peak times, and inventory carries no risk. On high volume deals, suppliers can modify fabrication lines to significantly reduce costs. One printer product team secured more than 15% discount on committed forward contract in addition to volume discounts! The supplier modified a conventional process based on HP's binding, forward commitment. The resulting cost reductions yielded an additional 15% savings to HP.

Less certain demand is satisfied through flexible quantity agreements. Flexible agreements are the most common supplier arrangement in our industry, so creative modifications of these agreements are usually easy to pull together with suppliers. Fabrication suppliers provide pricing discounts for committed "upside volumes," especially when the volumes are high with potential to grow. Discounts often increase as more volume is purchased. Making these commitments binding eliminates supply risk and provides further cost savings. A significant percent of HP's



memory requirements are met through these binding but flexible agreements. Contract horizons generally match HP's product lifecycles time and/or supplier capacity lead-times. The longer the horizon, the deeper the price discounts and the more binding the supply commitments.

Demand that is least likely to materialize can often be satisfied through the open or spot market. As these sources dry up, secondary-sourcing options can be used such as brokers, auctions and product recycling programs. These approaches mean higher prices, but are often a better solution than carrying inventory. And, the supply risk associated with these approaches is often less than expected. HP's customer support teams realized significant inventory savings by recovering critical parts from unsold products. They also found consistent supply for low volume microprocessor demand through auctions, saving on inventories subject to severe price erosion.

#### 3.4. Completing the picture with setting strategic objectives

Demand forecast scenario generation begins the process of building a procurement portfolio. Constructing price and component availability scenarios using a similar approach completes the measurement of risks associated with securing supply for critical components. Once these risks are measured and known, procurement objectives for managing the risks can be set quickly and easily. HP manages to these objectives with binding commitments are tailored structured contracts between HP and its suppliers, as described in Section 3.2.



Choosing the appropriate quantity and pricing term to meet a specific procurement objective results in a tailored structured contract. A portfolio of several such tailored structured contracts can be executed to meet different procurement objectives.

The incremental value of the procurement risk management approach is through the sharing of risks between HP and the supplier. This is driven by the need for the party bearing the risk to be rewarded for it. Risks that HP can better manage are borne by HP. For example, HP can better manage risks due to uncertain demand for HP's products than a supplier can. By entering into a quantity commitment with a supplier, this demand risk is borne by HP and in turn the supplier rewards HP through better pricing terms. In cases where supplier explicitly manages quantity and especially pricing risks, HP rewards the supplier through better quantity and/or pricing commitments. This contrasts with traditional industry practices where buyers do not make quantity commitments thereby imposing all demand risk (and associated costs) on the supplier.

### 3.5. [The need for forward-looking procurement metrics](#)

Procurement metrics currently used across the industry are mostly backward looking, focusing mainly on measuring past performance such as material price per-unit paid and its reduction over time, inventory levels and costs over time and shortage costs over time, etc. This measurement approach constrains procurement professionals and their organizations from anticipating and responding to significant changes in supplies and customer markets. The few metrics that are future looking are



typically limited to specifying target material price reductions and maximum inventory levels.

HP's forward-looking procurement metrics account for 1) the impact of procurement uncertainties, and 2) the interplay between various dimensions of uncertainty. The combined impact of demand, price and availability uncertainties is captured as the average and standard deviation in material, inventory and shortage costs. The need to capture the interplay between the competing dimensions of price, inventory and shortage cost is important for making effective short term trade-offs. For example, to obtain lowest expected price per-unit in increasingly supply constrained market; the strategy might call for large inventory buys or fixed quantity commitments at the expense of larger than desired inventory levels and inventory holding costs. Using the total cost measure defined as the sum of material price, inventory and shortage cost at any future point in time is useful for capturing such interplay between the various dimensions.

#### 4. HPRisk PRM software

We have developed the HPRisk suite of PRM software to support the implementation of the risk management process. The suite is composed of 3 components, namely HPHorizon demand scenario software, component cost forecasting software, and HPRisk contract valuation software.

##### 4.1. HPHorizon demand scenario software

Current demand planning software systems capture and aggregate 'point' forecasts for products and components. HPHorizon software augments these planning systems by determining high



and low demand scenarios. This software also determines and then corrects biases in the point forecasts. The proprietary analytics embedded in the software analyze historical forecasts and current demand trends to determine the uncertainty in the forecasts. HPHorizon software is used by planning teams at HP to periodically assess the uncertainty in demand forecasts for products and components.

#### 4.2. Component cost forecast scenario software

The hi-tech components such as memory and LCD panels exhibit significant cost uncertainty that if left unmanaged can significantly impact HP's profitability. Measuring the uncertainty in future cost of such components is the critical first step. Financial-engineering analytics is used by Wall-Street to measure the cost uncertainty of stocks, bonds, currencies and interest rates. These models however cannot be directly applied to model the cost uncertainty of hi-tech components, as the latter exhibit dynamics that are different than the former. We have developed proprietary analytics that model the unique cost dynamics of hi-tech components. These analytics have been individually adopted and embedded into easy-to-use software to forecast cost uncertainty by the way of high, base and low scenarios of memory and LCD panels. Our proprietary analytics can be adopted to forecast cost uncertainty of other manufactured commodities such as plastics, chemicals, steel, etc.

#### 4.3. HPRisk contract valuation analysis

Since the PRM approach is based on forward contract commitments to price and quantity terms, it is



critical that these contracts be appropriately analyzed to maximize benefits and minimize the risk that the contracts will underperform short-term sourcing alternatives. Furthermore, for a given commodity there could be several overlapping contracts, each with different quantity, pricing, and cash-flow structures. The value of a contract may depend greatly on what other contracts are in place. Given such a portfolio of structured contracts, the optimal quantity to be bought from the different contracts at any period in time will depend not only on the current demand, price and availability, but also on the specific structure and terms of the contracts. Contract valuation analytics calculate, using a common framework, forward-looking expected material, inventory, and shortage costs for a given portfolio of contracts considering the full range of possible outcomes for price, demand, and availability uncertainties.

The contract valuation analytics have been incorporated into a easy-to-use software HPRisk. Thus HPRisk automates complex calculations across a full range of price, demand, and availability scenarios required to measure procurement risks, supports “what-if” analysis, and head-to-head portfolio comparisons to aid negotiation and financial due-diligence of complex sourcing contracts and arrangements.

The innovations in the HPRisk suite of PRM software have resulted in five patent applications thus far.

## 5. The PRM business process

Risk management by its very nature is a cross-functional process. We have developed a cross-functional PRM business process that links and defines the roles and responsibilities of procurement, planning, supply chain operations, finance and marketing. HP's risk management process is simple in structure but rigorous in execution, schematically shown in Fig. 3. Strategy and governance for a particular commodity typically includes approving procurement objectives, establishing metrics and reviewing performance of any existing portfolio of deals. Strategy and

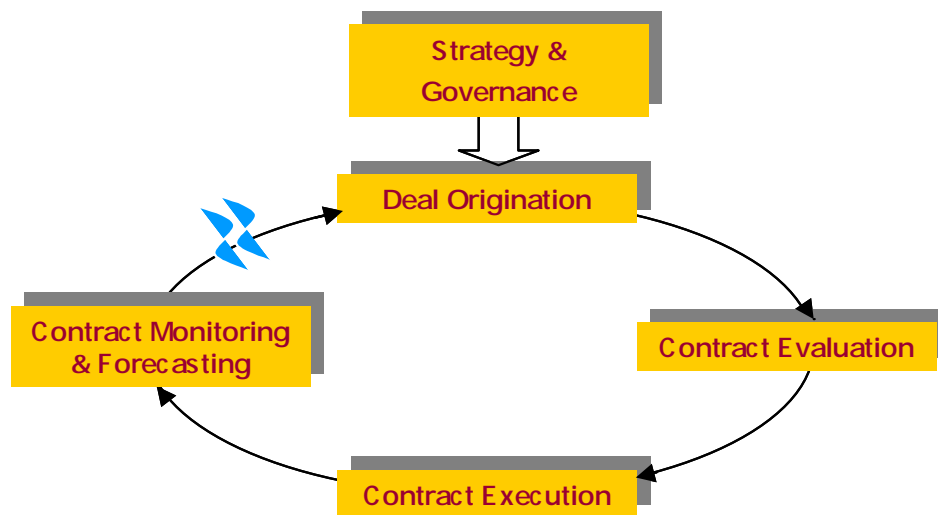


Fig. 3. HP's procurement risk management process

governance for product specific commodities is managed at the business level while commodities common across products are managed more centrally. The deal origination process guides the design of structured contracts to meet procurement objectives and to manage current



product and component market uncertainties. For company-wide contracts, commodity managers specify contract terms (originate) that satisfy specific product or divisional objectives, and then a team of commodity managers integrate these specifications into a single contract to leverage purchasing power. .

These contracts are evaluated during the Contract Evaluation phase to determine their future performance against objectives under various conditions of demand, price and supply uncertainty. Specific attention is paid to situations under which a contract would perform worse than buying without binding terms and conditions. HPRisk suite of software tools are used to evaluate the performance of structured contracts. Reports from such tools are easily generated to support ongoing negotiations and for management review and approval.

Once the proposed contracts are approved, these contracts are negotiated and executed using traditional or eSourcing methodologies.

The contract monitoring process guides 1) the backward-looking measurement of HP's and supplier's performance against commitments made in the structured contracts, and 2) the determination of the past performance of a structure contract (or combination of contracts) when compared to previously established metrics, and 3) future performance of an existing portfolio of contracts under changed forecast scenarios for demand, price and availability. Effective processes to measure HP's performance against commitments is an IT challenge for companies



like HP since it involves aggregating actual purchases by HP divisions and its agents (ODM's, CM's), data which dispersed in several ERP systems. HP's IT roadmap includes an enterprise infrastructure and application software to support aggregating actual purchases and then comparing them to commitments under structured contracts.

A rigorous process is being instituted to estimate demand, price and availability uncertainty for forecast scenario generation. The forecasting process forms the cornerstone of HP's risk management process, as credible forecast scenarios drive contract valuation and monitoring processes. The forecasting process involves estimating uncertainty by analyzing historical demand, price and availability data using software tools described above, and modifying these estimations of uncertainty using input from market analysts for price and availability uncertainty, and HP component demand uncertainty.

## 6. Benefits from implementing PRM

Over the past 5 years, HP has had success in developing procurement risk management framework, process and software, and implementing the risk management approach across HP's business units for the procurement of key strategic commodities. PRM has been applied at HP for a range procurement situations from direct procurement of components to indirect and services procurement. In direct procurement PRM has been applied to standard components such as memory, hard disk drives, and plastic, to custom components such as microprocessors,



ASICs, and custom assemblies. In indirect and services procurement PRM has applied to energy spare parts, and advertising procurement. This is wide range of application illustrates the power and generality of the PRM approach.

The impact of PRM on HP's spend over the past four years is shown in Fig. 4. The incremental benefit of implementing PRM are due the categories below:

1. Material costs savings: PRM deals with quantity commitments lower the supplier demand risks, while also enabling the supplier to cut costs through more efficient planning and production processes. The suppliers share some of this value with HP by the way of discounts on material costs. Through such PRM quantity commitments, HP has obtained incremental material cost discounts up to 5% for standard components, and an even higher discount for custom components, indirect and services procurement.
2. Cost predictability: PRM deals with specific pricing terms enable HP to proactively manage cost uncertainty. A significant portion of memory is procured using PRM deals thus enabling HP to obtain cost predictability required to protect margin on large customer deals.
3. Assurance of supply (AoS): Managing component demand and availability uncertainties is a key objective for PRM at HP. PRM deals have improved AoS



for several commodities even under conditions of an industry-wide shortage. For example, about a year ago there was an industry-wide shortage for memory, but the PRM deals executed by a particular HP business unit ensured that they obtained 100% of their demand from the suppliers.

4. Inventory cost reductions: The precise measurement of demand uncertainty using PRM software enables HP to optimize inventory levels internally and externally at supplier sites. Such optimization has cut inventory driven costs by several percentage points for commodities implementing the PRM framework.

Over the past 5 years implementing PRM has enabled over \$100 million dollars in incremental savings. Given the risk sharing aspects of PRM, the suppliers have benefited substantially as well. The quantity commitments that HP makes to suppliers, as opposed to just exchanging non-binding forecasts, has lowered supplier's demand risks; suppliers of several strategic commodities have locked-up a significant portion of their capacity through PRM deals with HP. Some suppliers are making commitments to their suppliers (who are HP's 2<sup>nd</sup> tier suppliers) tied to HP's quantity commitments to them. This results in quantity commitments cascading deeper into the supply chain resulting in a significant drop in the order volatility through the supply chain, and thus a reducing the "bull-whip effect". Therefore the PRM approach has the effect of smoothing the supply chain.



Given that the PRM approach is very new to HP and the manufacturing industry as a whole, we developed supporting infrastructure including process consulting and training to enable the commodity, planning, finance and marketing managers to learn and apply PRM. Over 750 HP employees have undergone PRM training courses over the past 5 years.

Procurement risk management is thus transforming HP's internal planning, procurement and supply chain processes, and HP's relationship with its suppliers through a win-win risk sharing partnership.

The success to date is the result of continuous innovation and process discipline, executive support, great talent, and most importantly the interest and patience shown by HP's employees in learning and implementing the procurement risk management approach. HP has an ambitious program to continue leading the industry and setting the industry standards in this important new business discipline. HP will also be the core provider of consulting, analytical solutions and software for procurement risk management.

## 7. Contact information

Please contact the authors for more details on procurement risk management.

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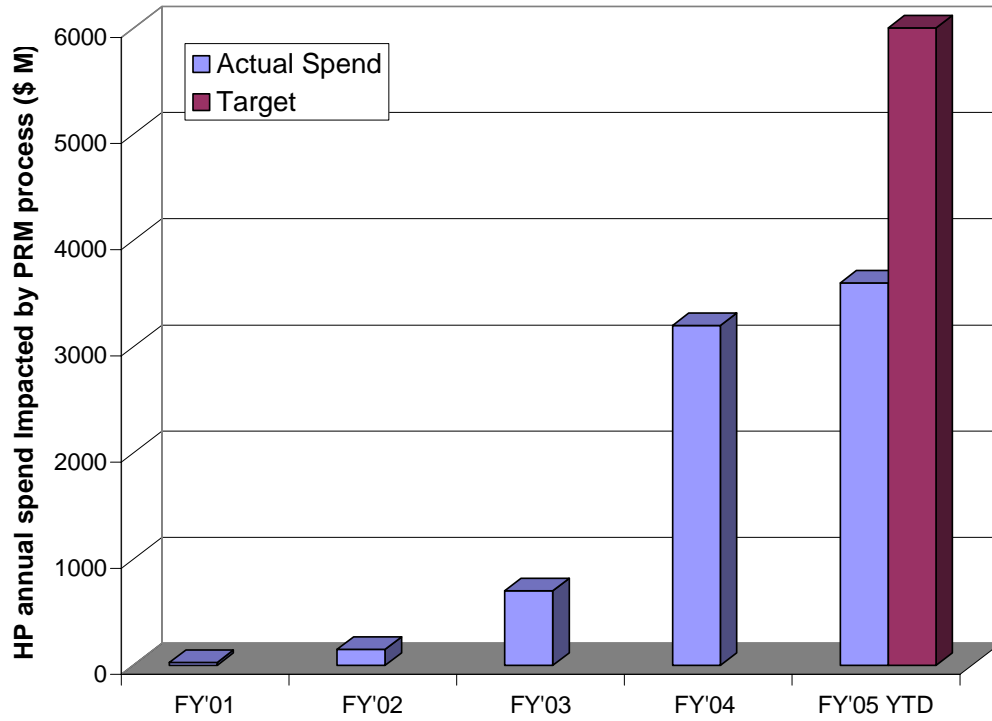


Fig. 4. HP annual spend impacted by the PRM process and tools